

GARDENING STEP BY STEP

Easy-to-follow advice for great results

Material previously published in *Planting a Small Garden*, *Low-maintenance Garden*, *Easy Pruning*, and *Vegetable Gardening*






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STEP BY STEP





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Key to plant symbols

Soil preference

- Well-drained soil
- Moist soil
- Wet soil

Preference for sun or shade

- Full sun
- Partial or dappled shade
- Full shade

Hardiness ratings

- ❄❄❄ Hardy plants
- ❄❄ Plants that survive outside in mild regions or sheltered sites
- ❄ Plants that need protection from frost over winter
- Tender plants that do not tolerate any degree of frost

Disguising boundaries

A visible boundary, such as a fence or wall, can make a yard feel small and claustrophobic. Concealing boundaries with plants will radically improve the appearance of a yard, transforming it into an attractive space.

Pictures clockwise from top left

Back fence disguise In many small yards, the most obvious boundary is the back fence, which, if visible, immediately gives away the length of the yard. By creating a mixed border directly in front, using a range of plants that will grow as tall as, or taller than, the fence, you will succeed in blurring the edges of your lot. Make sure the border is a reasonable depth: a narrow strip in front of the fence, deep enough for only one plant, is likely to draw attention to the boundary rather than disguise it.

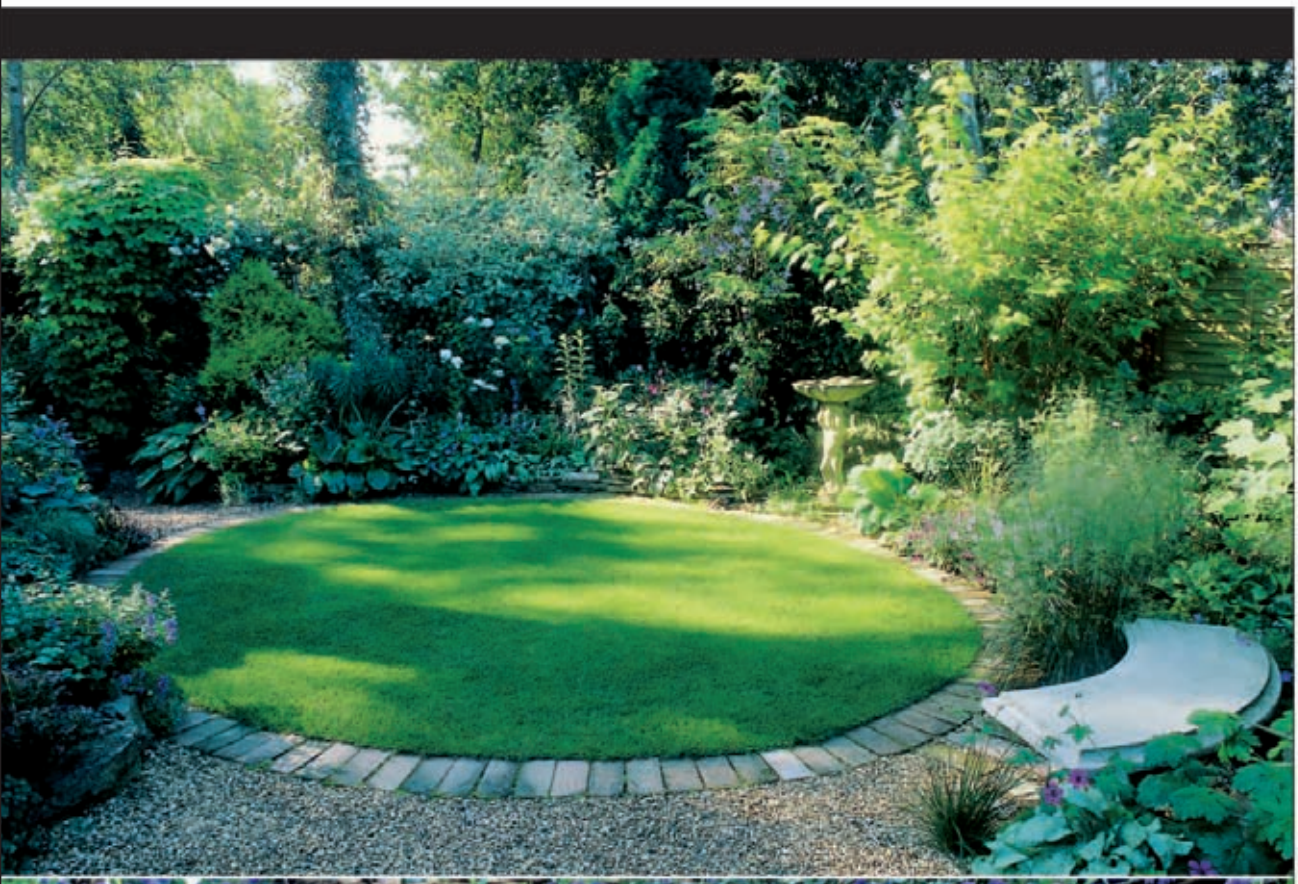
False perspective One of the most effective ways to disguise a boundary and also make a yard seem larger is to create a false perspective. For example, in a yard that appears short, make the borders running down the sides of the yard taper outward so that they are wider at the far end, making the yard appear longer. Another visual trick is to draw the eye away from the boundaries with a central, circular lawn or paved area, and surround it with dense plantings. Evergreen shrubs will ensure that the effect lasts all year.

Plant screen Dividing up the yard with various plant screens so that the entire yard is never completely visible from any one position will help make it feel larger and shift the emphasis away from the boundaries. Even a small lot can be divided up in this way using trellis or woven willow screens as supports for climbing plants; these also help to maximize growing space.

Courtyard enclosure Having a small garden does not mean that you should restrict yourself to small plants; in fact, doing so serves to underline a yard's limited size. Positioning a selection of quite large plants in front of fences or walls in generous-sized beds that have been pushed to the edges of the lot will help to maximize space in the center of the yard, creating a courtyard. The plants will also help to hide fences and walls.









Using color

The color provided by flowers and foliage is particularly valuable in a garden. It can be used in a number of different ways, perhaps to evoke a particular mood or to give areas of the garden a theme or look.



Pictures clockwise from left

Rich colors If you spend a fair amount of time enjoying your garden from indoors, it makes sense to provide displays of rich color that are easily visible from the house, perhaps in pots and containers on the patio, or in beds and borders close to the windows. Harmonious colors that blend well together create a strong but restful feel; use softer, pastel hues farther away from the house because they show up better at a distance than saturated colors.

Monochrome planting A garden or border composed of mostly white-flowering plants creates a cool, calming feel that is most striking at dusk, when the blooms glow in the fading light. Try using cream and pale yellow flowers, as well as very pale pink and blue ones, to prevent the effect from becoming stark and clinical. Silver-leaved and variegated plants will provide interest once the flowers have faded.

Hot hues Fiery colors, such as reds, oranges, and intense pinks, demand attention, but they should be used with care: they attract the eye away from softer shades and, if planted at the far end of the garden, may make the yard feel smaller. Often the simplest way to deal with hot-hued plants is to group them together and create a condensed and spectacular injection of color. Alternatively, combine them with contrasting shades, such as rich blue or purple, to mitigate the effect.

Serene green It is important to remember that green is also a color, and is the most commonplace in virtually every garden. There are many different shades of green but, generally, it has a restful effect, and gardens that are planted for foliage tend to be serene spaces. Set against other colors, though, green generally fades into the background, so use plants with variegated foliage or white or pastel-colored flowers to shine out and provide additional interest.



Focal points

Gardens often benefit visually from a dramatic or arresting focal point, be it a statue, pot, or plant, which provides a point of reference within the design where the eye can rest.

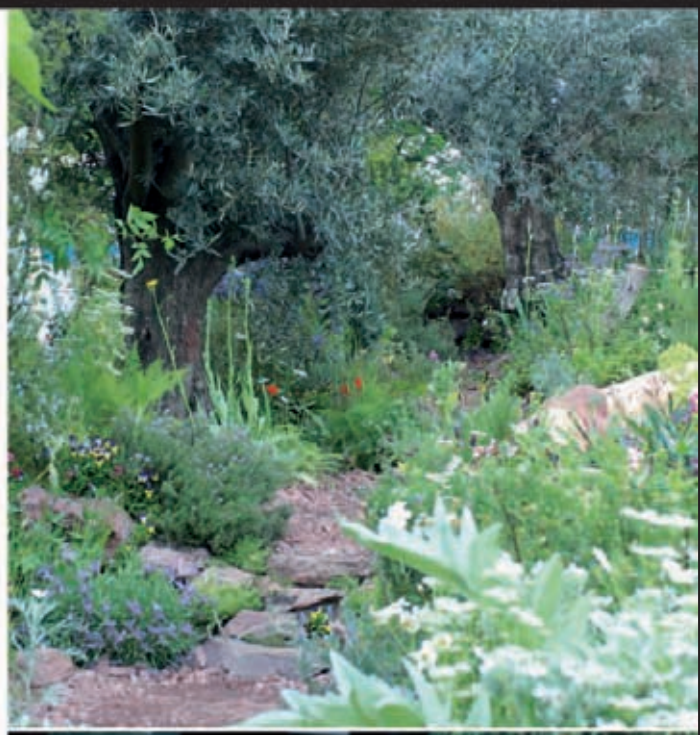
Pictures clockwise from top left

Eye-catching trees In a garden that seeks to recreate the wild, focal points need to be natural objects, such as rocks or specimen plants. In this Mediterranean-style garden, the gnarled trunks and silvery foliage of a pair of old olive trees are as arresting as any classical sculpture.

Winding steps Even a utilitarian feature such as a flight of steps can provide a focal point, as long as it is well executed. Winding steps passing through lush foliage lead the eye on to brighter, more vibrant flowers and foliage, which then act as a visual stopping point.

Dramatic containers Attractive pots and containers, planted or otherwise, are one of the simplest ways of creating a focal point. Used alone or in groups, they can be placed in a border, on a patio, or at the end of a pathway, perhaps terminating a vista. Large, impressive pots are often best left empty; others can be enhanced with a dramatic plant, such as a *Dasylirion*.

Focus on color Brightly colored plants make small-scale focal points in beds and borders. The vivid flowers of bulbs, such as these orange tulips, provide short-term accents, lifting other plantings and heightening interest.









Themed planting schemes

Some of the most successful gardens are developed around a particular theme or idea that helps to bind the planting and design together. Selecting plants that fit the overall concept helps evoke the correct spirit and feel, which, in turn, lends a touch of authenticity to the garden.





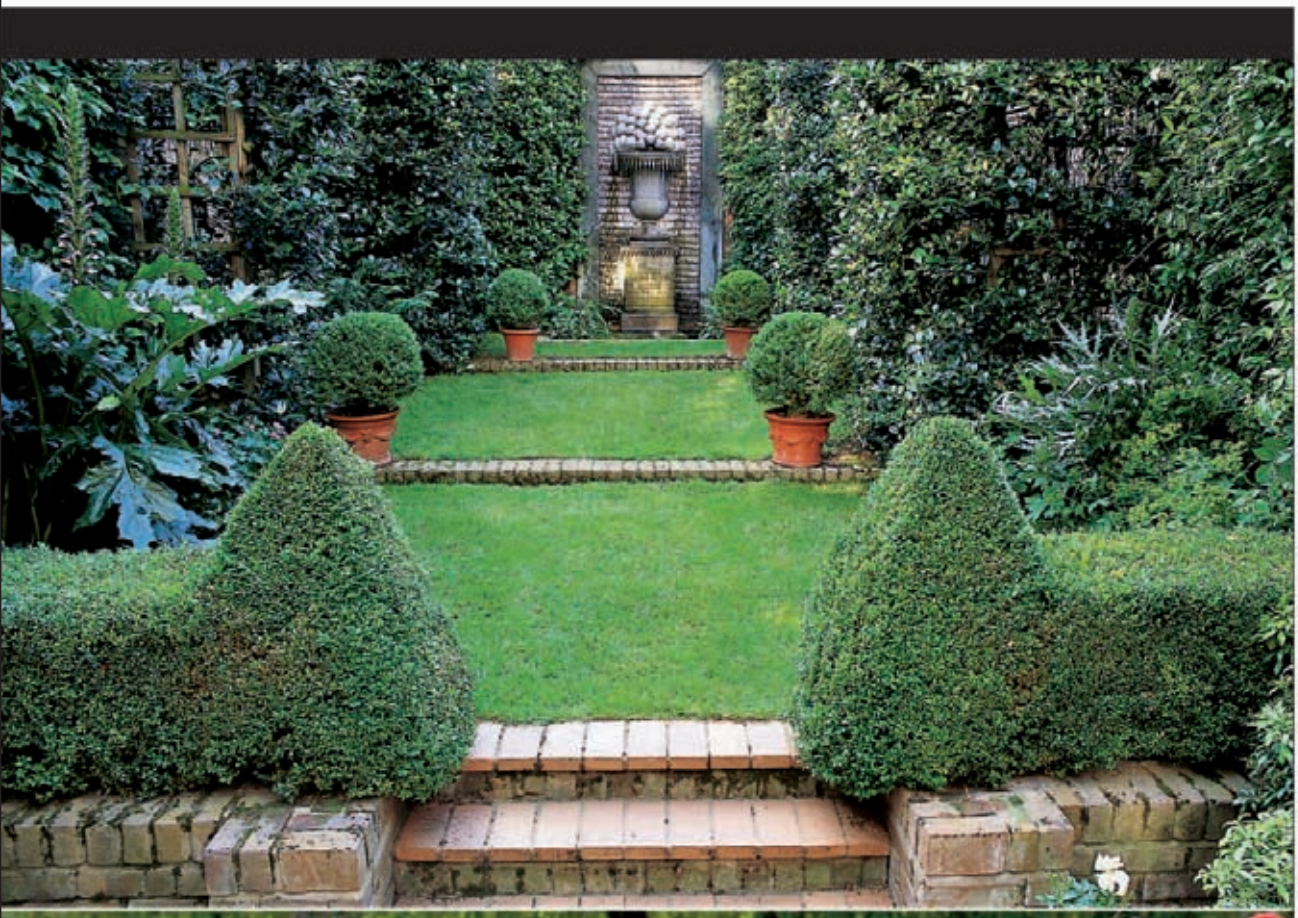
Pictures clockwise from top left

Lush and subtropical There are many hardy and borderline hardy plants that can be used to create a subtropical-style garden. Generally, the lush feel is provided by foliage plants. Large specimens of hardy *Trachycarpus* palms, bamboos, phormiums, and tree ferns will provide structure; in summer, containers can be filled with tender plants such as begonias, cannas, *Lantana*, and gingers (*Hedychium*), which produce exotic flowers.

Classic Italian Italianate gardens tend to be rather formal, with plenty of topiary and clipped evergreens, such as boxwood (*Buxus*). The layout is usually simple and the planting restrained, limited to a few favorites, such as acanthus, agapanthus, olives, slender conifers, jasmine, and herbs. Classical statuary plays an important role, often terminating a vista, and specimen plants in containers may feature, perhaps used along a terrace to introduce a sense of repetition and rhythm to the garden.

Meadow planting Informal and naturalistic, meadow planting uses a limited palette of different plants mixed randomly together in large groups. These schemes work well in large, open expanses and tend to be short-lived—many of the plants used are annuals, such as poppies (*Papaver*) and cornflowers (*Centaurea cyanus*). However, perennials can also feature, and the planting style can be scaled down to more modest-sized borders.

Moroccan oasis Water is a vital element for a Moroccan theme, and a wall fountain, perhaps with a blue-tiled surround, would make an ideal feature. Most of the plantings should be in pots—pelargoniums, date palms, agaves, and other succulents are suitable choices—but avoid having too many plants. A few large foliage plants in darker corners, and climbers, such as *Trachelospermum*, scrambling up the walls would also fit in very well.





Themed planting schemes *continued*



Pictures clockwise from top left

Mediterranean style Gravel, terra-cotta pots, and a sunny site all help to create a Mediterranean feel. Avoid filling the garden with too many plants—the general scheme should not be too lush—and try a few formal elements, such as clipped boxwood balls. Olive trees in pots can spend summer outside, while more permanent plants could include lavender (*Lavandula*), Cistus, and one or two exotics, such as Yucca.

Asian calm Japanese-style gardens often feature a few manicured plants, such as Japanese maples (*Acer japonicum*), dwarf pines, bamboos, *Ophiopogon*, and *Ilex crenata,* set in a rock and gravel landscape. Strategically positioned bonsai specimens add a dramatic touch to the overall theme.

Cottage effects Borders overflowing with flowers are typical of cottage gardens. Old favorites include delphiniums, foxgloves (*Digitalis*), Shasta daisies (*Leucanthemum* x *superbum*), and lavender (*Lavandula*), with sweetly scented roses and self-seeding annuals completing the informal look.

Modern mixes Architectural plants, such as tree ferns, phormiums, and *Tetrapanax*, are the mainstays of highly designed contemporary gardens. Grasses and small-scale, naturalistic planting schemes are also popular, their soft foliage forms contrasting well with hard modern landscaping materials, such as concrete, glass, and steel.





Seasonal interest

Watching the way a garden changes its character with the seasons is part of the joy of gardening. To get the most from your garden, it should be designed and planted to provide interest for every day of the year. Each season has its own distinctive feel and appearance, and a well-designed garden will include plants that reflect this.







Spring (*top right*) As the days lengthen, the garden quickly wakes from its winter rest. Bulbs, such as daffodils and crocuses, produce showy flowers, while other herbaceous plants begin to emerge from the ground, and deciduous shrubs and trees produce fresh, verdant growth.

Summer (*right*) For many gardeners, this season represents the high point of the year. Most herbaceous plants reach their zenith, filling out borders and blooming for several months, while annuals flower and set seed. Leafy trees and shrubs provide structure, and tender plants flourish in the mild summer months.

Fall (*bottom right*) This is arguably the most colorful and plentiful season. Late-flowering plants, such as asters and dahlias, blaze in borders, while many trees and shrubs produce vivid berries and fruits. The leaves of many deciduous plants also brighten up the garden with rich hues before falling. In the moist and still warm conditions, some bulbs, such as *Colchicum*, provide a welcome freshness.

Winter (*opposite page*) Once all the leaves have fallen, the shape and structure of the garden and its plants can be properly appreciated. This is a season of quiet, subtle beauty. Trees and shrubs, such as silver birch (*Betula pendula*) and *Cornus* with its red-colored stems, and evergreen plants, as well as the faded seedheads of herbaceous plants, provide interest. A few plants also produce delicate, often sweetly scented flowers. As cold weather sets in, frost and snow dust the plants, creating a magical feel.



Spring beds and borders

No season is more eagerly anticipated than spring. After the dark, cold days of winter, the garden bursts into life with verdant growth and colorful flowers, marking the start of a new gardening year. In late spring, many gardens look their freshest, resplendent with the soft, glowing greens of young foliage.

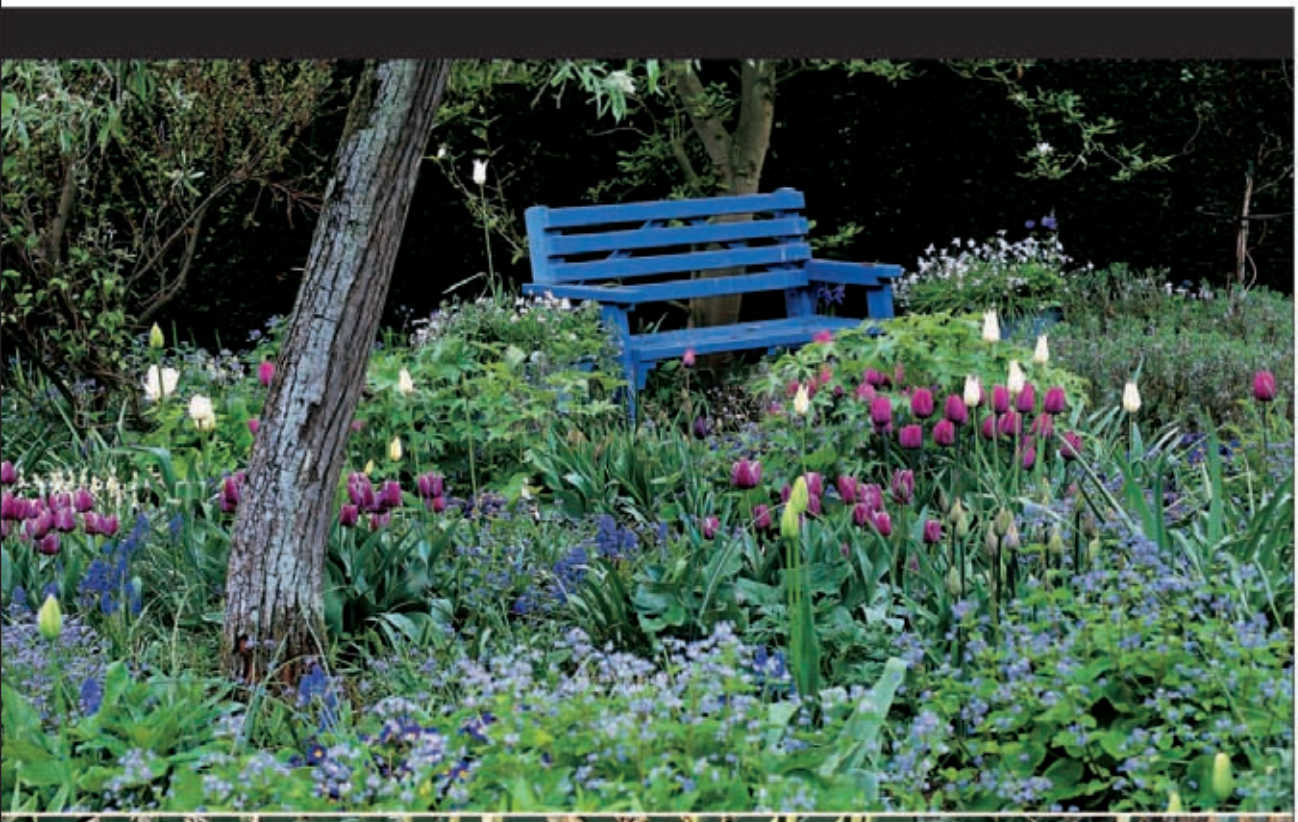


Pictures clockwise from left

Colorful climbers Walls and fences can be clothed with a range of different climbers that will flower in spring. Wisteria, grown for its waterfalls of scented purple or white flowers, is perhaps the best known. It is, however, a large plant and needs restrictive pruning to keep it manageable. Alternatives include *Clematis montana* in white or pink, and *Akebia quinata* with purple blooms, although these climbers are also potentially large. More suited to a small garden are *Clematis alpina, C. macropetala*, and the early honeysuckle *Lonicera periclymenum* 'Belgica' with its deliciously scented flowers.

Vibrant bulbs and early perennials In beds and borders, herbaceous plants push through the soil, growing quickly in the damp, mild conditions. Many will flower early, especially those that enjoy woodland conditions, such *as Pulmonaria, Primula, Dicentra, Doronicum, Epimedium,* and *Anemone.* Some of these perennials can be grown successfully with spring bulbs, such as tulips and daffodils, injecting extra interest into plantings and helping to mask yellowing bulb foliage as the season progresses.

Carpets of spring flowers In less formal areas of the garden, where a more naturalistic display is desired, it is possible to plant and even naturalize some bulbs in grass. Snowdrops (*Galanthus*) and crocuses that flower in early spring can be interplanted with fritillaries, tulips, daffodils (*Narcissus*), and *Camassia* to create a display that will last until early summer. Areas under mature trees are ideal for this kind of treatment, but avoid mowing the grass until the bulb foliage has died away.





Summer beds and borders

Summer is the season of unrestrained color, when most beds and borders are at their best. If well planted, the garden should provide a succession of flowers that lasts for months on end.

Pictures clockwise from top left

Mixing colors Planting a mix of herbaceous perennials and annuals is a quick and easy way to provide striking contrasts. Color-themed plantings that use a restricted color palette are effective at creating different moods. Contrasting colors evoke drama, while those that blend together produce a more relaxed feel.

Continuous color Many perennials run out of steam as the summer progresses, especially in times of drought or extreme heat. Others, though, can be relied on to flower well into fall, especially those that are natives of warmer climates, such as *Crocosmia* and *Rudbeckia*.

Calming foliage Without some order, too many bright flowers can become rather overpowering, especially in a small space. The mitigating effect of foliage can help create a calmer effect, softening bright colors. Silvery leaves, such as those of *Artemisia*, used with whites, creams, and pale pinks produce a cool feel; deep green foliage contrasts well with brightly colored flowers.

Summer bulbs Summer-flowering bulbs, such as lilies, gladioli, and *Galtonia*, are often overlooked but, planted directly into borders or put in pots and plunged into the ground, they pack a powerful punch of color.









Fall beds and borders

As the days shorten, color and interest in the garden come from new sources: the leaves of some plants acquire fiery tints, and fruits and seedheads replace many flowers. Some blooms are at their best during fall, too.



Pictures clockwise from left

Deciduous trees Trees and shrubs, such as Japanese maples (*Acer japonicum*) and *Rhus*, produce autumnal tints that provide a spectacular backdrop to other plantings. The colored leaves remain eye-catching once they have fallen, especially around the flowers of late-blooming perennials and bulbs, such as *Cyclamen*.

Structural seedheads Some summer-flowering perennials, such as *Echinops*, *Allium*, *Agapanthus,* and many grasses, produce attractive seedheads that last well into winter. They look particularly striking in the slanting fall light, decorated with cobwebs or, later, frost.

Colorful fruits Many shrubs and trees produce handsome, long-lasting fruits at this time of year; certain roses, in particular, carry ruby hips, as long as they are not pruned in fall. Consider leaving other plants unpruned, such as *Viburnum* and *Sorbus*, to help provide birds with food.

Perennial color Some perennials, such as *Aster, Chrysanthemum, Cyclamen*, and *Saxifraga fortunei*, will produce vibrant flowers until the first hard frost, and look wonderful in fall borders. They can also be useful in containers to inject color into areas of the garden that are of little interest at this time of the year.







Winter beds and borders

Gardens are often neglected in winter once most showy flowers have faded, but with the right plants, they can still be enchanting places at this time of year. Plants with winter interest often have special, rather subtle qualities, such as sweetly scented flowers, attractive stems, foliage, seedheads, berries, or structural shapes.





Pictures clockwise from top left

Winter flowers Hellebores, such as *Helleborus* x *hybridus*, are among the best winter-blooming plants. Flowering from midwinter to mid-spring, these clump-forming evergreen perennials are easily grown in light shade in any good soil, and form good ground cover when planted in drifts. Other perennials with winter interest worth seeking out include mauve-flowered *Iris unguicularis* and *Arum italicum* 'Marmoratum', with its white-veined leaves.

Transient beauty Frost and snow add an element of short-lived beauty to the garden in winter, often transforming it overnight. A light covering of snow or a hard frost can enhance structures, highlighting architectural features and plants and briefly changing the whole feel of a garden.

Scented highlights Mahonias are among the finest evergreen shrubs for winter, with their spiny foliage and sweetly scented yellow blooms, followed by blue-tinged berries. They are also useful for their architectural form, which makes them an attractive backdrop for other plants such as *Euonymus*, with its colorful fruit.

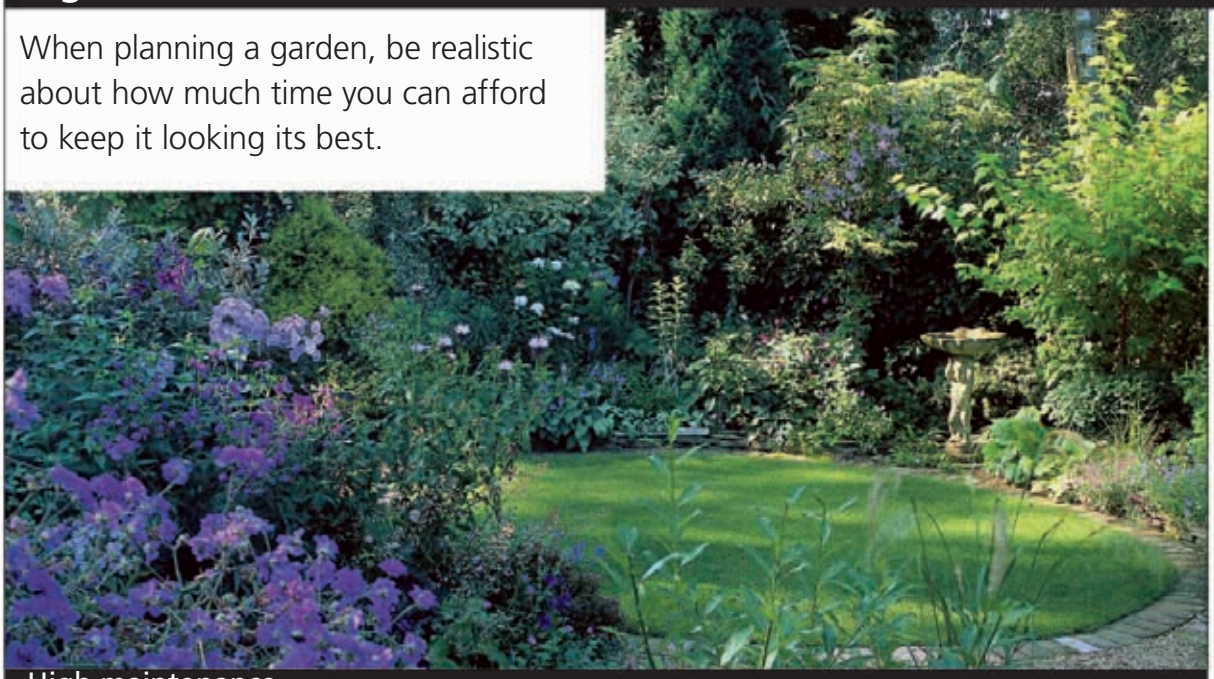
Graceful grasses The seedheads of some grasses will survive well into winter, providing a touch of unexpected grace to plantings, especially when dusted with frost. Translucent, they allow views through to plants behind, such as the fruit-laden branches of a crabapple (*Malus*).

Scented shrubs Some shrubs flower in winter, such as witch hazel (*Hamamelis*) with its orange, yellow, or red spiderlike blooms. Other shrubs worth considering for their delicious scent include the honeysuckle *Lonicera* x *purpusii* and *Chimonanthus praecox*.



High and low maintenance

When planning a garden, be realistic about how much time you can afford to keep it looking its best.



High maintenance

Gardens for plant lovers These gardens tend to be stocked with a wide range of choice plants, which need their specific growing requirements matched in order to grow well. Careful placing of plants and constant manipulation of growing conditions by gardeners will keep these gardens looking their best, and regular attention will be required to keep plants from outgrowing their space.

Dense planting Filling a garden with plants may reduce weeding, but competition for light and water causes problems. High-maintenance plants include dahlias, which may need planting and lifting each year, annuals grown from seed, plants with specific watering, feeding, or pruning needs, and those prone to pests and diseases. A lawn also needs weekly mowing to keep it looking good.

High-maintenance planting suggestions

- *Aster* (some)
- *Astrantia*
- *Buxus* (if kept clipped)
- *Canna*
- *Clematis* (some)
- *Cornus sanguinea* 'Winter Beauty'
- *Dahlia*
- *Dicksonia antarctica*
- *Echinacea purpurea*
- *Erysimum*
- *Helenium*
- *Hosta*
- *Lavandula* (lavender)
- lilies
- *Melianthus major*
- roses (some)
- *Sambucus racemosa* 'Plumosa Aurea'
- tulips



Tulip bulbs should be planted in late fall.



Hosta 'June', like all hostas, is loved by slugs.



Prune *Cornus sanguinea* in early spring.



Lilium regale bulbs should be planted in spring.



Low maintenance

Easy-care gardens These are a good choice for people who have little spare time but still want an attractive outdoor space. Lawns can be replaced with patios or decks, and the soil covered with a special membrane to cut down on weeding, and topped with bark or cobbles after planting. Irrigation systems can be installed, and plants chosen that do not need much attention.

Undemanding planting This can provide year-round interest and yet needs little attention. Large specimen plants provide immediate impact. Evergreen shrubs and trees are good because most need little pruning and do not drop leaves in fall. Minimal use of herbaceous plants lessens end-of-season work, and using well-spaced larger plants reduces watering and trimming.

Low-maintenance planting suggestions

- *Acer*
- *Arbutus unedo*
- *Aucuba japonica*
- *Choisya ternata* Sundance
- *Cotoneaster horizontalis*
- *Fatsia japonica*
- *Hemerocallis* (day lily)
- *Ilex aquifolium* 'Silver Queen'
- *Jasminum nudiflorum*
- *Mahonia*
- *Nandina domestica*
- *Phormium*
- *Photinia* x *fraseri* 'Red Robin'
- *Phyllostachys nigra*
- *Stipa tenuissima*
- *Trachelospermum asiaticum*
- *Vinca* (periwinkle)



Ilex aquifolium 'Silver Queen' has beautiful evergreen foliage.



Stipa tenuissima is a trouble-free, airy grass.



Hemerocallis 'Corky' is ablaze with golden blooms in summer.



Cotoneaster horizontalis has bright red fall berries.

Choosing a planting style

When planting your garden, if you decide to follow a particular style, first ensure that it is practical and fits your lifestyle.



What do you want?

Find inspiration for your yard by visiting other gardens, and looking at books, magazines, and television shows. If you long for a tropical garden with exotic plants, such as palms and other architectural specimens, you can achieve it with the use of containers on a sun-drenched terrace, even in cold regions.

What do you need?

If entertaining outdoors is important to you, a large patio with a dining/barbecue area will be useful, while a lawn is a good idea if children are likely to play in the yard in summer. Your lifestyle may dictate that you have a low-maintenance garden with plants that are easy to care for but look good all year. Consider also how much privacy you need.

Examine the visual appeal of your chosen scheme. Will you include plants with impact to create impressive planting schemes? Or would you prefer a themed garden with an exotic feel, or simply an oasis of tranquillity? When selecting plants, make sure you choose those that will suit the style of garden you have in mind.



Keeping it neat

A wonderful garden filled with unusual plants and flowers is all very well, but it may require a great deal of time to keep it in tip-top condition. When planting and designing a garden, decide how much time you can spare to care for it. Some planting styles require less effort than others to keep them looking good. A formal garden with a central lawn, for example, looks tidy once mown, but it may be better to reduce the area of grass or replace it with gravel or decking, if free time is limited. Planting in formal schemes tends to be confined to geometric-shaped beds or borders. Designs can be either high-maintenance, with a mix of perennials, annuals, and shrubs, or low-maintenance, with easy-care shrub borders.



A natural approach

For many people, choosing a naturalistic planting style, using drifts of perennials or a large number of native plants, creates a garden that feels at one with nature. With this approach, you may also decide to avoid using chemicals on your plants, and adopt organic growing methods. Encourage birds, insects, and other wildlife into your garden to enrich your gardening experience, and create curved or sinuous borders for your informal planting designs.



Planting style ideas

Setting a particular style for your planting and layout helps to create a feeling of cohesion, and makes selecting plants and garden objects much easier. The main hurdle is making a choice and sticking to it.

Asian

An authentic Japanese garden is difficult to create, and requires discipline and subject knowledge. It is possible to use elements from the style, however, to create a distinctive Asian feel. Minimalist lines, the use of certain plants, rocks, raked gravel or slate chips, and focal points, such as stone lanterns, prove effective. Colors are restrained, derived mostly from foliage; showy flowers are seldom used.

Planting suggestions

- *Acer japonicum* (Japanese maple)
- *Camellia sasanqua*
- *Ophiopogon* 'Nigrescens'
- *Phyllostachys nigra*
- *Pinus mugo* 'Ophir'

Maintenance tips Keep raked gravel weed- and leaf-free: the garden should appear immaculate.



Maple foliage provides vibrant color in an Asian-themed garden.

Knot gardens and parterres

Knot gardens are generally small-scale and feature low, clipped hedges, usually boxwood (*Buxus*) but sometimes *Santolina* or lavender (*Lavandula*), set out in simple patterns. Between the hedges are blocks of color, normally from bedding plants or colored gravel. Parterres are more ambitious in scale and design, but they also use low hedges with colorful flowers and often topiary. Both styles of garden are highly formal, labor-intensive, and best seen from above.

Planting suggestions

- bedding plants, e.g., dahlias, cosmos
- *Buxus sempervirens* (boxwood)
- culinary herbs
- *Santolina chamaecyparissus*
- *Taxus baccata* (yew)

Maintenance tips Clip the hedges 2–3 times a year to keep them neat.



A well-tended knot garden makes a fine garden feature, even without flowers.

Modernist

The overall feel of most modernist gardens is one of simplicity and restraint, with planting often taking second place to hard landscaping, giving a minimalist feel. Plants are carefully selected and sited, with architectural specimen plants providing instant impact. The palette of plants is usually limited, with a restricted color theme, and maximum use is made of form and texture. Broad sweeps of perennials and grasses, often planted in a naturalistic way, provide summer color.

Planting suggestions

- *Acer japonicum* (Japanese maple)
- *Dicksonia antarctica*
- *Fatsia japonica*
- *Phyllostachys nigra*
- *Stipa tenuissima*
- topiary shapes, boxwood (*Buxus*), yew (*Taxus*)
- *Verbena bonariensis*

Maintenance tips Modernist gardens tend to be naturally low-maintenance, but be sure plants are well watered, especially when they are establishing, and top off mulches of gravel or aggregates as required.



Clipped boxwood balls in a sea of lavender give this garden a modern twist.

Tropical

For sheer floral drama, few gardening styles can match a tropical border. These displays of exotic-looking plants, usually a mix of hardy and tender plants grown for both foliage and flowers, provide great interest in both summer and fall. Planting is informal, with plants massed together in profusion; huge bold leaves and vibrantly colored flowers predominate, while the displays improve as the season progresses. This style is labor-intensive, and displays usually last only until the first frost.

Planting suggestions

- *Canna*
- dahlias
- *Hedychium gardnerianum*
- *Melianthus major*
- *Musa basjoo* (banana)
- *Phoenix canariensis*
- *Phormium tenax*
- *Ricinus communis*

Maintenance tips Plant out a tropical border after the last frost date. Feed and water well for rapid, lush growth. Ensure that you protect tender plants well from winter cold.



Spectacular flowers and foliage provide high-impact summer displays.

Cottage

A traditional cottage garden represents many people's idea of the ultimate garden. Planting tends to be informal, but contained within a simple, formal layout, which is usually little more than a network of paths. Flowering herbaceous perennials predominate, and these gardens are usually at their best in early summer. Later on, roses and clematis provide plenty of color, and in winter, well-chosen shrubs lend the garden structure once the flowers have faded. Colors are often soft and muted, giving a relaxed feel.

Planting suggestions

- *Astrantia*
- delphiniums
- *Dianthus* (pinks)
- *Digitalis purpurea* (foxglove)
- geraniums
- *Philadelphus*
- *Ribes* (flowering currant)
- roses

Maintenance tips Regular additions of garden compost in spring will keep perennials growing well. Remember to divide clumps of herbaceous plants every 2–3 years for healthy growth.



Borders overflowing with flowers are typical of the cottage-garden style.

Contemporary

The contemporary garden is usually thought of as an extension of the home, a so-called "outdoor room" that often includes dining and seating areas. This modern and practical garden style often features expanses of paving or wooden decking, ideal for massed displays of brightly colored yet color-themed container plants in the summer. Beds tend to be filled with easy-care, usually evergreen plants, to provide year-round interest, and are often planted through a weed-suppressing membrane, topped with mulch to minimize aftercare.

Planting suggestions

- *Acer japonicum* (Japanese maple)
- *Astelia nervosa*
- *Aucuba japonica* (spotted laurel)
- *Photinia* 'Red Robin'
- *Choisya ternata*
- *Clematis armandii*
- *Pittosporum tenuifolium* 'Tom Thumb'

Maintenance tips Ensure that plants are well watered while establishing. Keep mulches topped off, and plant containers when frost has passed.



Wooden decking is used to give this garden a contemporary feel.

The effects of exposure

The direction in which your yard faces affects the amount of sunlight it receives, while altitude influences temperatures. Take both factors into account when choosing your plants.

Which way does your yard face? Simply observing how much sun your yard receives gives an idea of its orientation. To work it out accurately, use a compass. Stand with your back to your house wall—the reading from here shows the direction the yard faces. South-facing yards get the most sun, north-facing sites the least.





Morning: areas that are in sun now may be in shade by the afternoon.

Sunny and shady sites Some yards are sunnier than others as a result of their exposure and other factors, such as shade-casting buildings, but in all sites, the amount of direct sun and the sun's position in the yard change as the day progresses. A south-facing yard will have sun all day, a north-facing one much less, or perhaps none in winter.

Sunny gardens are usually more desirable, but shade does have its advantages. These gardens are cooler, have a more humid microclimate, and are less prone to drought. There are many wonderful shade-loving plants that will not tolerate direct sun, while in a sunny garden, slightly tender plants from Mediterranean regions, for example, flourish. The key is to work with what you have.

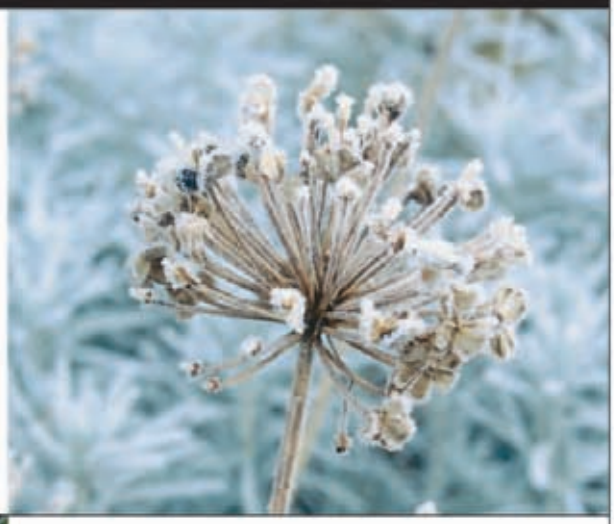


Midday: the sun is overhead, so the garden receives maximum sunlight.



Evening: as the sun sets, the glancing light casts soft shadows.

Beware frost pockets Frost occurs when temperatures fall below freezing. Spring frosts can be particularly lethal in the garden, especially where many near-tender plants are grown. Even on a local scale, some sites will be more vulnerable than others, usually in areas where pockets of freezing air develop. Cold air is heavy, and sinks to the lowest point. If it cannot escape, it collects, forming a "frost pocket." Here, frosts will be harder and linger longer, and you may get a frost when other areas remain above freezing. Gardens in valleys or in a hollow often suffer badly. Hedges or walls may create or worsen the effect, preventing cold air from flowing away. Thinning a hedge, using trellis instead of a solid barrier, or leaving a gate open on cold nights may help.





Creating microclimates Even within a single garden, you may notice great differences in the growing conditions. A border by a sunny wall or fence will be far warmer and drier than one in the shade, perhaps beneath a tree, which is likely to be more humid with a more even temperature range. A low-lying area will remain wetter than a border at the top of a slope, and some parts of the garden may be sheltered, others exposed. Gardeners can capitalize on these differences; even in small areas, they allow you to grow a wider range of plants. A sunny spot can be enhanced with a raised bed to improve drainage for tender plants; low-lying areas could be turned into a bog garden for moisture-loving plants. You can make a windy area more sheltered with a permeable barrier, such as a trellis.

Seasonal impact The direction your yard faces gives it particular properties throughout the year. A north-facing garden, or border in front of a north-facing fence, will receive little sun in winter, remaining cold and damp, but temperatures will be more constant than in a south-facing area that is warmed after a sunny winter day, only to be chilled at night. Plants exposed to constant chill also start into growth later, but are affected less by late frosts. While potentially dank in winter, a north-facing area offers a cool retreat in summer, and lush, moisture-loving woodland plants will thrive there. Spring bulbs take advantage of the sun spots under bare deciduous trees, areas that receive little light in summer. Sunny patios are ideal for tender plants, but may get too hot and dry in summer for some plants.



Understanding soil

Before you decide what to plant in your garden, take a look at the soil. The acidity or alkalinity of the soil and its composition determine what will grow, and an understanding of its properties helps you keep plants in good health.

Types of soil

Soil comprises two elements: a mineral portion (tiny particles of weathered rock, larger gravel, and stones) and an organic portion (plant and animal remains, and living organisms). The most important part of the soil is found in the top 12 in (30 cm). Below this lies less fertile subsoil.

Soil particle size, the amount of organic matter, and available water determine soil characteristics. The smallest soil particles will form clay, those a little larger create silt, and even bigger particles form sandy soil. Soil with a mix of different particle sizes is known as loam.

The descriptions below will help determine your soil type:

Chalk soil Soil that is pale and contains chunks of white limestone (usually the underlying rock), and often flint, is chalk soil. It is free-draining and fertile, often rather thin, and almost always alkaline.

Peat soil Distinctively dark, peat soil is rich in organic matter that helps it retain soil moisture. Peat forms where wet, acidic conditions stop plant and animal remains from decomposing fully. Peat soil is usually acidic.

Clay soil Composed of more than 25 percent moisture-retaining clay particles, clay is heavy to dig and may be waterlogged in winter (it dries out in summer). Organic matter is easily trapped, resulting in good fertility.

Silty soil With particles not as fine as those of clay soil, silt is also fairly moisture-retentive and fertile. Silty soil tends to be dark in color, which is the result of the accumulated organic matter that it often contains.

Sandy soil Sandy soil is easy to spot, being light and free-draining. It is composed of relatively large individual soil particles that allow water to drain quickly.

Testing the soil's acidity or alkalinity

Use a soil-testing kit to assess the acidity or alkalinity (pH) of your soil—the results will indicate what plants will grow well. Carry out several tests across the garden, using soil from just below the surface. Soil pH is measured on a scale of 1–14. Above neutral (7) is alkaline, below is acidic; pH 6.5 is usually considered the optimum.



Following the kit's instructions, add garden soil and water to the test tube provided and shake the contents well.



Compare results from around the garden with the chart provided: a red/yellow color shows an acidic soil; dark green an alkaline one.

Testing sandy soil

To determine whether your garden has sandy soil, and thus may need regular irrigation and boosting with organic matter, carry out a simple test to examine the texture of the soil. Take your sample from just below the soil surface and repeat at intervals across the garden to ensure an even overall result.



Rub a small amount of soil between your fingers. If the soil has a gritty, granular feel, it is likely to contain a high proportion of sand.



Try to squeeze the soil into a ball—the grains of sandy soil will not stick together, but if it is loamy, the shape may hold a little.

Testing clay soil

To check if you have clay soil, and thus soil that may become waterlogged in winter and be more difficult to dig than other soil types, remove small samples of soil from different spots around the garden from just below the soil surface. Clay soil will feel quite sticky and heavy when shaped in the hand.



Try to mold the soil in your hands—the particles of clay soil will hold together well and change shape when pressed.



Heavy clay can even be rolled into a thin cylinder; it will often appear smooth and shiny.

Making the most of your soil

Different types of soil have differing characteristics, some aiding cultivation of certain plants, others providing a challenge to gardeners. Various techniques can be used to improve the soil to maximize its potential.

Sandy soil

Advantages Sandy soil is free-draining, which prevents plants from becoming waterlogged in winter and aids the survival of species sensitive to wet conditions. It is easy and light to dig all year, and warms up quickly in the spring.

Disadvantages In dry conditions, plants will often require extra irrigation, and moisture-loving species will be unreliable in this soil. Sandy soil has a tendency to be poor, so you will need to apply plenty of plant food and organic matter.

Improving sandy soil Dig in large amounts of organic matter each year to help improve the soil's ability to hold water and nutrients. Mulches such as gravel help to keep in moisture. Digging in clay may also be useful.

Plants for sandy soil

- *Acacia dealbata*
- *Calluna vulgaris* 'Silver Knight'
- *Catananche caerulea*
- *Cistus* x *hybridus*
- *Convolvulus cneorum*
- *Cotoneaster horizontalis*
- *Erysimum* 'Bowles' Mauve'
- *Euphorbia characias*
- *Euphorbia rigida*
- *Grevillea* 'Canberra Gem'
- *Helianthemum* 'Rhodanthe Carneum' ('Wisley Pink')
- *Helleborus argutifolius*
- *Iris unguicularis*
- *Melianthus major*
- *Olea europaea* (olive)
- *Pittosporum tobira*
- *Romneya coulteri*
- *Rosmarinus officinalis* (rosemary)
- *Solanum crispum* 'Glasnevin'
- *Verbena bonariensis*



Abutilon x *suntense*



Allium hollandicum 'Purple Sensation'



Artemisia alba 'Canescens'



Bupleurum fruticosum



Lavandula stoechas



Perovskia 'Blue Spire'

Clay soil

Advantages Clay soil is usually highly fertile and many plants thrive in it. It also retains water well. The more clay soil is worked, the better it is for planting, as the soil gradually becomes more crumbly and drainage improves. Avoid working the soil when it is wet and easily compacted.

Disadvantages Despite its high fertility, clay soil has a number of problems that can be hard to tackle. In winter it may become waterlogged and impossible to dig. Attempts to work the soil in this state usually create compaction, where the soil particles are compressed, resulting in yet further waterlogging. In summer, the opposite problem occurs; clay bakes hard and even simple digging can be impossible. Even when the soil is manageable, it is heavy, breaking into large clods, and it is slow to warm up in spring.

Improving clay soil The key to success is often simply perseverance. By adding organic matter to the soil, you will eventually improve its structure, making it more crumbly and easier to work. In small areas, perhaps in a raised bed, dig in horticultural sand. Avoid walking on the garden when it is waterlogged and do not dig the soil when wet. Try to carry out most planting in spring or fall when the soil is more manageable. In areas where waterlogging is severe, you may need to install drains.

Plants for clay soil

- *Alchemilla mollis*
- *Arum italicum* subsp. *italicum* 'Marmoratum'
- *Aruncus dioicus*
- *Aucuba japonica* (spotted laurel)
- *Berberis darwinii*
- *Buxus sempervirens* (box)
- *Campanula glomerata*
- *Carex elata*
- *Cornus sanguinea* 'Winter Beauty'
- *Digitalis purpurea* (foxglove)
- *Geranium*
- *Hemerocallis* (day lily)
- *Hosta*
- *Hydrangea macrophylla* 'Lanarth White'
- *Iris laevigata*
- *Jasminum nudiflorum*
- *Leycesteria formosa*
- *Mahonia* x *media* 'Buckland'
- *Viburnum tinus* 'Eve Price'



Anemone x *hybrida* 'Honorine Jobert'



Euphorbia characias



Iris sibirica 'Perry's Blue'



Malus 'John Downie'



Primula pulverulenta



Sambucus racemosa 'Plumosa Aurea'

Making the most of your soil *continued*

Alkaline soil

Advantages Alkaline soil enables you to grow a wide range of plants; many vegetables (such as members of the cabbage family) will not grow as well in acidic soil. Ornamentals, such as clematis, are said to grow better in alkaline soil, and the finest rose gardens tend to be in alkaline areas. This soil suits earthworms; some pests and diseases, such as clubroot, are less of a problem.

Disadvantages There are certain plants that simply will not grow in alkaline conditions and, unfortunately, they are often among the most desirable. Rhododendrons, camellias, *Pieris*, some magnolias, and other woodland plants, such as *Uvularia* and *Trillium*, need the cool, moist, acidic soil associated with their native habitats. These plants are known as "calcifuges" or lime-haters. Some acid-loving plants may survive in alkaline soil but will look sick, with yellowing leaves (chlorosis). Alkaline soil tends to be deficient in manganese, boron, and phosphorus, all of which are important for healthy plant growth.

Improving alkaline soil You cannot, as such, improve alkaline soil, since a high pH can be both good and bad. Gardeners are advised to grow what suits their particular soil. Many acid-loving plants can be grown in containers, or in a raised bed filled with ericaceous (acidic) compost. Where the soil pH is neutral or just alkaline, years of adding organic matter may lower the pH enough for some smaller acid-loving plants.

Plants for alkaline soil

- *Aquilegia* McKana Group
- *Aster* 'Coombe Fishacre'
- *Buddleja davidii* 'Dartmoor'
- *Buxus sempervirens*
- *Choisya ternata* Sundance
- *Clematis*
- *Cotoneaster horizontalis*
- *Erica carnea* 'Foxhollow'
- *Erysimum* 'Bowles Mauve'
- *Hebe*
- *Hibiscus syriacus* 'Oiseau Bleu'
- *Iris unguicularis*
- *Lavandula stoechas*
- *Mahonia* x *media* 'Buckland'
- *Nepeta* x *faassenii*
- *Phormium* 'Yellow Wave'
- *Primula vulgaris*
- *Pulsatilla vulgaris*
- roses
- *Salvia officinalis* 'Purpurascens'
- *Sedum* 'Herbstfreude'



Alchemilla mollis



Campanula glomerata



Clematis cirrhosa



Cotinus coggygria 'Royal Purple'



Jasminum nudiflorum



Lonicera (honeysuckle)

Acidic soil

Advantages Some of the most spectacular garden plants, including rhododendrons, *Meconopsis*, and *Desfontainia*, will grow well only in acidic soil. Other species, such as *Hamamelis*, may survive in alkaline soil but simply perform better in acidic soil. Few garden plants will not tolerate mildly acidic soil, although a very low pH will limit your choices. Acidic soil is often associated with woodland conditions and tends to be cool and moist.

Disadvantages Acidic soil, though usually rich in organic matter, can be quite poor, especially if it is also sandy. To improve it, dig in plenty of well-rotted manure each year. Very peaty soil can, conversely, be waterlogged and require draining. This is often the most acidic of all and you may need to add lime to it for a range of plants to thrive. Most fruits and vegetables do not like strongly acidic soil and other plants simply will not grow—these are known as "calcicoles" or lime-lovers. Acidic soil is often deficient in phosphorus and may have too much manganese and aluminum for healthy plant growth.

Improving acidic soil If your soil is strongly acidic, you may need to increase the pH to broaden the range of plants you can grow. Adding spent mushroom compost is an excellent way of doing this. Powdered lime is an alternative. However, most gardeners usually feel that mildly acidic soil is desirable, and simply grow plants that enjoy their conditions.

Plants for acidic soil

- *Astilboides tabularis*
- *Betula* (birch)
- *Camellia*
- *Cercis canadensis* 'Forest Pansy'
- *Cornus canadensis*
- *Corydalis flexuosa*
- *Daphne bholua* 'Jacqueline Postill'
- *Desfontainea spinosa*
- *Digitalis purpurea* (foxglove)
- *Hedychium densiflorum*
- *Leucothoe fontanesiana* 'Rainbow'
- *Meconopsis*
- *Photinia* x *fraseri* 'Red Robin'
- *Pieris*
- *Primula pulverulenta*
- *Rhododendron*
- *Romneya coulteri*
- *Skimmia* x *confusa* 'Kew Green'
- *Stewartia monadelpha*
- *Uvularia grandiflora*



Acer palmatum



Calluna vulgaris 'Silver Knight'



Carex elata 'Aurea'



Cornus kousa var. *chinensis*



Grevillea 'Canberra Gem'



Hydrangea quercifolia

Making a border

Flower and shrub borders provide color, scent, and seasonal interest, making them an essential part of the garden. Follow these basic steps when planning and preparing your borders to ensure their success through the year.





1 Decide where in the yard you want your border and mark out its shape. For a curved edge, use a garden hose. Make sure the border is not too narrow and that its shape fits well within the overall layout of the garden.



2 Using a half-moon edger or a small spade, carefully slice through the grass, following the contours of the hose. Make sure the cuts line up properly and push the full depth of the cutter into the ground.



3 With a spade, begin stripping off the sod. Cut it into manageable-sized squares from above, then slide the blade of the spade under the roots of the grass. Try to avoid removing an excessively deep layer of soil.



4 Stack the sod in a spare corner of the yard, grass side down. The soil in this sod is nutrient-rich and should be reused. After several months, the grass will die off and the pile can be cut up, sifted, and dug into the borders.

Making a border *continued*



5 Dig over the exposed soil with a fork, pushing the tines down to their full depth. Remove old roots, large stones, and debris that you unearth, and break up large clods of soil. Work the soil until it has a crumbly texture.



6 With a spade, spread about 2 in (5 cm) of organic matter, such as well-rotted farmyard manure or garden compost, over the surface of the border. Turn the compost into the soil, and mix it in evenly.



7 If the soil is heavy or poorly drained, spread a 3-in (8-cm) layer of coarse sand or gravel over it, and dig this into the top 6 in (15 cm) of soil with a spade. This will help open up drainage channels through the soil in the root zone.



8 Using a soil rake, remove any remaining stones, roots, or debris that may have worked their way up to the surface. Then, with the flat back of the rake, carefully level off any mounds and hollows.

9 Set out the plants, still in their pots, on the ground, adjusting their positions until you are happy. Pay attention to their eventual size, flower and foliage color, and season of interest to achieve your desired effect.

Tip for success



To stop soil from spilling out onto the lawn, consider adding edging to the front of the border before planting. Use a level to make sure the edging is level.

Finishing touches

To help set off planting and add a touch of "polish" to the garden, small additions, such as edgings and mulches, can make a big impact.

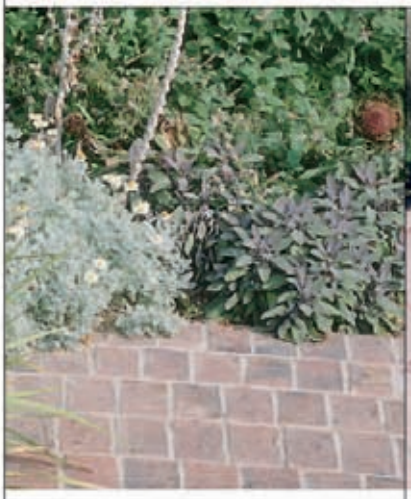


Soft lawn edging

It is surprising how much difference a well-edged lawn makes to the overall look of a garden. Where borders meet grass, trim with edging shears after mowing to maintain the shape of the lawn. Edging irons are also useful for reshaping when required. Plants that spill from borders onto the lawn may add a touch of informality, but will damage the lawn in the long run.

Choosing a hard edge

Borders that meet hard landscaping materials require less maintenance than soft edging. Sprawling plants are best grown next to hard surfaces where the border's shape can be maintained more easily. Use paving for formal or informal situations, and areas where grass struggles to grow, such as in shade or next to narrow paths.



Brick edging Laid as a path or in a single row between a border and lawn, or along gravel paths, bricks create a traditional feel. They also blend well with plantings.



Paved edging Where paving meets a border, attractive informal effects can be achieved. Allow plants, such as lavender, to billow out from flower beds, softening the hard layout.



Wood edging If you have border soil to retain, wood edging is an easy-to-install option. Partially conceal with plantings to help it blend in, and apply wood preservative to prevent rotting.

The benefits of mulching

Mulches help to conserve soil moisture, reduce weeding, and provide a decorative element, and some add organic matter to soil, improving its fertility and promoting plant growth. A mulch is simply a layer of material spread over the soil surface, and different situations and plantings require different types. Avoid applying them too thickly—about 1¼ in (3 cm) is ideal—or over the crowns of plants. Mulches are usually applied in early spring.



Organic matter Garden compost or well-rotted manure is an ideal mulch because it aids plant growth, improves the soil, and helps retain moisture. It needs to be reapplied every year.



Cocoa shells Lightweight and easy to apply, cocoa shells break down, enriching the soil. They are, however, easily disturbed by wind, animals, or birds, and can look unsightly.



Gravel Long-lasting and inexpensive, gravel preserves moisture in summer and keeps standing water away from sensitive plants, such as alpines, in the winter. It is heavy to apply.



Decorative mulches Colored glass chips, crushed seashells, and other decorative mulches are ideal for pots and containers. They will reduce weeds and conserve moisture.



Weed membranes Laid beneath mulches before planting, porous membranes drastically reduce weeds. Adding plants after a membrane has been laid can be tricky, though.



Bark chips Lightweight, organic, and weed-suppressing, bark chips are a popular mulch, but as they slowly break down, they may remove valuable nitrogen from the soil.

Making your own compost

Making compost from your kitchen and garden waste is a sustainable and environmentally friendly way of recycling. Applied as a mulch, compost helps to improve the fertility and moisture-retaining qualities of your soil.



Types of composters The basic way of making compost is to pile it into a heap, but this can be unsightly, and better compost is often achieved more quickly using a composter. The simplest structures are bays, usually made of corrugated plastic or metal, in which waste is piled. Wooden compost bins are easier on the eye, and can be built at home from scrap wood; otherwise you can buy ready-made bins, often with slatted sides or vents for air circulation. Effective and inexpensive, lightweight plastic compost bins (*right*) are also a popular choice.

Filling your bin Almost any vegetable matter can be added to a compost bin, and the more diverse the range of materials, the better the compost. It is also important to keep woody and nitrogen-rich leafy materials in proportion: you should try to include about twice as much woody material (twigs, paper) as nitrogen rich-material (grass, kitchen scraps). Mix grass cuttings with woodier clippings or even shredded paper, because a thick layer of grass will inhibit important air movement. Chop bigger cuttings into small pieces and avoid adding weeds with seeds, or persistent perennial weeds. Place a layer of coarser twigs in the bottom of the bin and then add the material in layers. Spread a little farmyard manure between layers to help speed up the composting process.



Leafy material adds nitrogen and moisture:
- Grass cuttings and weeds
- Kitchen vegetable waste
- Fallen leaves
- Herbaceous plant clippings
- Sappy hedge trimmings
- Windfall fruit
- Old bedding plant material



Woody, carbon-rich material improves airflow:
- Woody plant clippings and twigs
- Shredded paper
- Scraps of cardboard
- Untreated wood shavings
- Stems of herbaceous plants
- Bark mulch



Layer woody and leafy material in your compost pile.

Speeding up composting Nitrogen-rich manure contains microorganisms that promote composting, so add it to your pile to help the material break down more quickly. Alternatively, you can buy special compost additives. Turning the pile also improves air circulation, speeds up rotting, and ensures that all the material is composted.



Tip for success

Too much wet, green, nitrogen-rich material, such as grass cuttings, will quickly turn the compost pile sour and smelly. Mix it with coarser woody matter in layers, and aim to turn the pile regularly.

Planting a perennial

Perennials are plants that grow from year to year, and many are long-lived. But for these plants to perform well as they mature, they must be planted and established with care.





1 Place the plant in its pot on the ground in a position that suits its growing needs and not too close to other plants. The soil in the pot should be thoroughly soaked before planting to help give the plant a good start.



2 With a spade, dig a hole wider and deeper than the size of the plant's container. Add organic matter, such as garden compost, to the base of the hole and dig it in well. Pour some water into the hole before planting.



3 Remove the plant carefully from its pot. If the roots tightly encircle the root ball, the plant is pot-bound and the roots need to be teased out gently. Place the plant in the hole, slightly deeper in the ground than when it was in its pot.



4 Backfill around the root ball, firming the soil as you go and ensuring that the plant stands straight in its hole. Avoid mounding the soil around the stems; the plant should be in the center of a shallow depression. Water well.

Planting a tree

Planting a tree may seem a simple task, but these plants are long-lived and should be planted well and given the appropriate aftercare if they are to fulfill their potential in years to come.





1 Soak the root ball of the tree in its container before planting. This will compensate for any water loss from the roots during the planting process and ensure that the tree settles into its position well.



2 With a spade, dig a planting hole about three times as wide as the diameter of the pot and 12 in (30 cm) deep (most root activity takes place in the top layer of soil). Lightly fork the base and sides of the hole.



3 Check the depth by putting the pot in the hole and placing a pole across the top—it should rest on both sides of the hole and on the top of the root ball. You may need to add or remove soil in the hole.



4 Gently remove the root ball from its pot—the pot should slide off easily, leaving the root ball intact. Carefully tease out some of the larger encircling roots, to help the tree root into the surrounding ground more successfully.

Planting a tree *continued*



5 Stand the tree in its final position. Drive a sturdy stake into the ground close to the tree trunk and at a 45° angle over the root ball, to avoid damaging the roots. Make sure that the stake faces into the prevailing wind.



6 Backfill the hole with soil, working it in around the roots. Unless the soil is poor or sandy, do not add organic matter because this seems to prevent the roots from spreading out in search of nutrients. Firm the soil in gently.



7 Tie the tree quite loosely to the stake with a tree tie, about 18 in (45 cm) from the ground, to allow the stem to flex in the wind. Check the tie regularly and loosen it as the tree girth expands, to prevent damage to the bark.



8 Water the tree well after planting and during dry periods for the first couple of seasons. Add a mulch of well-rotted garden compost, about 3 in (8 cm) deep, around the tree. Keep the mulch about 6 in (15 cm) away from the trunk.



9 Over the next two to three years, use sharp pruners to remove any damaged wood or branches that spoil the tree's shape, such as crossing, rubbing branches. Do not leave stumps—cut fairly close to the main stem.

Planting a shrub

Shrubs form the backbone of a planting scheme, providing important structure as well as flower and foliage effects. Before planting, check the plant label for the shrub's preferred site and soil, since moving it at a later date will be difficult.



Tip for success

Once planted, apply a top-dressing of fertilizer above the roots in spring. Later watering or rain will wash it down.



1 Soak the plant thoroughly in its pot. With a spade, dig a large hole, approximately two to three times the diameter of the pot. Remove any old roots and large stones, and break up the soil in the base of the hole with a fork.



2 To check that the hole is the correct depth, place a pole across the top; it should rest on both sides of the hole and on the top of the root ball. Position the plant with its best side facing the direction from which it will be viewed.



3 Remove the pot; it should slide off easily, leaving the root ball intact. Tease out any encircling roots. Add organic matter, such as garden compost, to the removed soil, especially if it is poor. Backfill around the root ball.



4 Firm the soil down gently. The plant should sit at the center of a shallow depression, which will assist watering. Spread a mulch of organic matter around the plant, keeping it away from the stems. Water the plant well.

Planting a climber

Climbing plants are particularly useful in small gardens because they add height without too much bulk, maximizing the use of limited space. They are also a quick and effective way of covering dull fences and garden structures.

Tip for success



A system of vine eyes threaded with wire along a fence is perhaps the simplest and least visible way of providing support for climbers. The system is easy to attach and allows plants to grow to their full potential.



1 Dig a hole twice the diameter of the root ball, 12–16 in (30–40 cm) from the fence. To support the stems and achieve good initial coverage, construct a fan from canes pushed into the soil and angled toward the fence.



2 Make sure the plant is well watered, then position it in the hole at an angle pointing toward the fence. Carefully remove the pot and any supporting stakes. Separate multiple stems growing from the base of the plant.



3 Backfill the hole with the removed soil mixed with some organic matter, such as garden compost. Firm the soil gently as you go. The plant should be at the center of a shallow depression, to aid watering and establishment.



4 Select the stems to be trained up the canes, tying in one to two stems per cane with gardener's twine. Spread a mulch of bark chips or organic matter over the soil to keep in the moisture and suppress weeds.

Sowing annuals outside

Many hardy annuals, such as California poppies (*Eschscholzia*), are best sown *in situ* outside, avoiding the root disturbance that occurs when seedlings are removed from their pots. Plants grow quickly to give fine summer displays.

Tip for success



The fine soil of a seedbed is attractive to cats, and young seedlings may be disturbed by birds. To avoid these problems, protect the area with twiggy sticks pushed into the ground.



1 Select an open area without any competing plants for sowing the seeds. Lightly fork over the soil, breaking up large clods, and then remove large stones, weeds, and debris with a rake. Work the soil into a fine, level tilth.



2 Make drills (shallow depressions to sow seed into) in the soil by pushing a pole or bamboo cane into the soil surface. Drills make it easier to identify seedlings; weed seedlings are unlikely to emerge in straight lines.



3 Place the seeds into the palm of your hand, and aim to pour the seed gently from a crease as you pass your hand along the drill. Do not sow the seed too thickly. Larger seeds can be placed in the drill with your fingertips.



4 Lightly cover the drills with fine soil and water well using a can with a fine spray to avoid disturbing the seeds. Keep the seedbed moist and remove any weeds. When the seedlings emerge, carefully thin out close-growing plants.

Sowing hardy annuals

While many hardy annuals can be sown outside *in situ*, it is often safer and more rewarding to plant seeds in pots under cover, in a cold frame, a greenhouse, or on a sunny windowsill.



Tip for success

Always label your seeds using a waterproof pen. Include the name of the plant and the date of sowing.



1 Fill a clean or new 3½-in (9-cm) pot with a good-quality seed-sowing potting mix, leaving a ¾–1¼-in (2–3-cm) gap beneath the rim of the pot. Firm the soil gently to create an even surface for the seeds.



2 Using a watering can with a fine spray, dampen the potting mix, being careful not to disturb it by splashing too much. Alternatively, stand the pots in a tray of water until the surface is moist, then remove.



3 Sow the seed evenly. Large seeds are easy to position, but fine seeds should be spread from the palm of the hand. Some seeds need to be covered by a fine layer of soil or vermiculite; follow the instructions on the seed packet.



4 When the seeds have germinated and produced a few sets of leaves, harden them off by placing the pots outside during the day for a few weeks. Then you can plant them out in the garden.

Sun-baked gravel garden

In a sunny corner, a gravel garden offers the chance to grow an interesting range of plants: herbs with aromatic leaves, plants with silvery foliage, alpines, and some grasses are good choices. These plants enjoy growing through gravel because it keeps excessive moisture away from their stems, yet helps to keep the roots cool and moist. Gravel also warms up quickly during the day and retains warmth at night.

Border basics

Size 10 x 6 ft (3 x 2 m)
Suits Herbs, low-growing plants, annuals, bulbs, gray-leaved plants
Soil Well-drained, poor soils
Site Open and sunny, not too exposed

Shopping list

- 2 x *Parahebe perfoliata*
- 1 x *Helictotrichon sempervirens*
- 1 x *Thymus pulegioides* 'Bertram Anderson'
- 1 x *Santolina chamaecyparissus*
- 1 x *Aurinia saxatilis* 'Variegata'
- 1 x *Rosmarinus officinalis* Prostratus Group

Planting and aftercare

Dig over the site, removing large stones, debris, and weeds; spot-treat perennial weeds like bindweed, because they will be hard to remove once gravel is spread. Add organic matter, such as well-rotted garden compost, to the soil, and dig in plenty of gravel to at least a spade's depth to help provide good drainage.

Place any feature rocks or driftwood as focal points. Position plants with plenty of space between each one. Add sand to the planting holes and place plants slightly higher than the soil surface. As you spread the gravel, work some into the crowns of plants. Water well. Once settled, the plants will need watering only in the driest periods.



Parahebe perfoliata



Helictotrichon sempervirens



Thymus pulegioides 'Bertram Anderson'



Santolina chamaecyparissus



Aurinia saxatilis 'Variegata'



Rosmarinus officinalis Prostratus Group



Cottage garden medley

This ever-popular, typically English style of planting uses mainly herbaceous flowering plants in a relaxed, informal way. The flowers are usually pale pastel colors with a few brighter hues added as highlights. Traditional cottage garden favorites include delphiniums, foxgloves (*Digitalis*), verbascums, and penstemons, as well as woody plants such as roses and lavender (*Lavandula*). Although not low-maintenance, such planting schemes are certainly beautiful in summer, when the plants all bloom together in profusion.

Border basics

Size 6 x 5 ft (2 x 1.5 m)
Suits A mixture of herbaceous perennials
Soil Well drained
Site Sunny with some shelter from wind

Shopping list

- 3 x *Delphinium grandiflorum* 'Summer Blues'
- 3 x *Verbascum* x *hybridum* 'Snow Maiden'
- 3 x *Delphinium* 'New Zealand Hybrids'
- 3 x *Geum* 'Blazing Sunset'
- 3 x *Penstemon digitalis* 'Husker Red'
- 3 x *Digitalis purpurea*

Planting and aftercare

Prepare the border before planting, adding well-rotted farmyard manure. Check that drainage is good; if not, add some gravel. Planting in spring is best for perennials. Three of each plant will guarantee a decent show of flowers in the first year, and odd numbers of plants look best in informal plantings. Plant in small drifts, with taller plants positioned toward the back, but do not be too rigid about this—the effect should appear relaxed. The delphiniums, in particular, may need staking with canes. In fall after flowering or the following spring, cut down old foliage, and mulch with manure.



Delphinium grandiflorum 'Summer Blues' ❄❄❄ ◑ ☼



Verbascum x *hybridum* 'Snow Maiden' ❄❄❄ ◊ ☼



Delphinium New Zealand Hybrids ❄❄❄ ◑ ☼



Geum 'Blazing Sunset' ❄❄❄ ◑ ◊ ☼



Penstemon digitalis 'Husker Red' ❄❄ ◑ ◊ ☼



Foliage effects

Raised beds are easy to maintain and can be constructed almost anywhere. For a contemporary look, planting should be colorful and stylish, and provide year-round interest. Pick plants that complement each other in a range of colors and textures—here, much of the interest is provided by foliage.

Bed basics

Size 3 x 3 ft (1 x 1 m)

Suits A range of nonvigorous plants with similar requirements

Soil Moist but well drained

Site Sunny, and sheltered from strong, drying winds

Shopping list

- 1 x *Euphorbia amygdaloides* 'Purpurea'
- 1 x *Sedum spectabile*
- 1 x *Carex comans* 'Frosted Curls' or *Molinia caerulea* subsp. *caerulea* 'Variegata'
- 3 x *Ophiopogon planiscapus* 'Nigrescens'
- 1 x *Heuchera* 'Plum Pudding'

Planting and aftercare

Any raised bed must have adequate drainage holes; without them the plants will rot. A layer of crocks or polystyrene at the base will help water to run away freely. In a small bed, use a soil-based potting mix blended with some organic matter, such as well-rotted manure; a large bed should be filled with good-quality topsoil with some well-rotted garden compost worked into it. Leave the bed for a few days to let the soil settle. Position shorter plants, such as the *Ophiopogon*, at the edges, and taller plants, like the *Euphorbia*, in the center of the bed. Water well. Make sure that the soil never dries out, weed the bed regularly, and cut down any faded herbaceous growth, such as the *Sedum* flowerheads, in fall.



Euphorbia amygdaloides 'Purpurea'



Sedum spectabile



Carex comans 'Frosted Curls'



Ophiopogon planiscapus 'Nigrescens'



Heuchera 'Plum Pudding'

Alternative plant idea



Molinia caerulea subsp. *caerulea* 'Variegata'



Tree and shrub combination

Trees and shrubs can be used to create exciting combinations for beds and borders. They also tend to require less maintenance than herbaceous plants, and retain structure and sometimes foliage over winter. Include a range of growth habits and sizes, foliage color and texture, plants with attractive flowers and others with winter interest, all of which will thrive in the given conditions.

Border basics

Size 10 x 8 ft (3 x 2.5 m)
Suits Wide range of shrubs and small trees; compact selections are best
Soil Acidic, free-draining, moisture-retentive soil
Site Sunny and sheltered

Shopping list

- 1 x *Aucuba japonica* 'Picturata'
- 1 x *Cotinus* 'Grace'
- 1 x *Phormium tenax* 'Atropurpureum'
- 1 x *Grevillea juniperina*
- 1 x *Magnolia grandiflora* 'Goliath'
- 1 x *Pittosporum tobira* 'Nanum'

Planting and aftercare

Dig the soil thoroughly, adding plenty of rotted garden compost. Space plants out well because they will be difficult to move when larger. The biggest plant is likely to be the magnolia, so put it at the back of the border. The evergreen gold-splashed foliage of the *Aucuba* is a focal point, so position the plant centrally. Its rounded form contrasts well with the spiky *Phormium*. The lower-growing *Pittosporum* and *Grevillea* (which needs acidic soil) can be placed at the front. The *Cotinus* balances the composition, its purple leaves matching those of the *Phormium*. Make sure all are well watered and firmed in at planting. Some pruning, especially of the *Grevillea* and *Cotinus*, may be required later, to stop them from outgrowing their positions.



Aucuba japonica 'Picturata'



Cotinus 'Grace'



Phormium tenax 'Atropurpureum'



Grevillea juniperina



Magnolia grandiflora 'Goliath'



Pittosporum tobira 'Nanum'



Spring hot spot

Vibrant, fiery colors are not solely for late summer; there are various perennials and bulbs that provide similar hues in late spring, although the effect is different. The reds, oranges, and yellows of plants such as tulips, the first lupines, *Doronicum*, and *Euphorbia* can be combined with verdant new growth to create a glowing display.

These hot color combinations contrast with the whites, blues, and cool yellows found in abundance elsewhere at this time, making a dazzling display.

Border basics

Size 6 x 6 ft (2 x 2 m)
Suits Early-flowering perennials, bulbs (especially tulips), perennials with attractive young foliage
Soil Any fertile and moist soil
Site Sheltered with some direct sun

Shopping list

- 20 x *Tulipa* 'Ballerina'
- 20 x tulips of contrasting shape
- 5 x *Polygonatum* x *hybridum*
- 5 x *Euphorbia griffithii* 'Fireglow'
- 5 x *Foeniculum vulgare* 'Purpureum' (just visible)

Planting and aftercare

Prepare the border by adding plenty of organic matter, such as garden compost, to the soil. Position the perennials first, with the tallest plant, Solomon's seal (*Polygonatum*), toward the back. Interplant the *Euphorbia* with the bronze fennel (*Foeniculum*), leaving reasonable spaces in between to allow planting pockets for the tulips. Plant the bulbs at three times their depth, in eight groups of five. Avoid mixing the tulip cultivars because this will dilute the effect.

The *Euphorbia*, in particular, will suffer if the soil becomes too dry. Watch out for sawfly larvae on the Solomon's seal.



Tulipa 'Ballerina'



Polygonatum x *hybridum*



Tulipa (pinky red)



Euphorbia griffithii 'Fireglow'



Lush leaves for shade

In a shaded courtyard or corner of a terrace, a modern planting scheme in a raised bed can create a dramatic, rather exotic, effect. Many foliage plants grow well in some shade, and a mix of evergreen shrubs and herbaceous plants provides year-round interest. A tall bamboo (*Phyllostachys*) will catch the breeze, adding a dynamic element to the planting, while a few variegated plants, such as hostas, help lift the planting out of the shadows, as will painting the backdrop and raised walls a pale color.

Border basics

Size 8 x 5 ft (2.5 x 1.5 m)
Suits Lush foliage plants
Soil Fertile and moisture-retentive
Site Sheltered, semi-shaded corner

Shopping list

- 2 x *Hosta* 'Francee'
- 1 x *Hebe salicifolia*
- 3 x *Fatsia japonica*
- 1 x *Phyllostachys nigra*
- 1 x *Miscanthus sinensis* 'Variegatus'
- 3 x *Ophiopogon planiscapus* 'Nigrescens'
- 2 x *Hedera helix* (ivies)

Planting and aftercare

Make sure the bed has enough drainage holes to prevent waterlogging. Choose a good quality topsoil and add well-rotted manure to it before planting. Position taller plants at the back (the bamboo will look best in the corner). The hostas, *Ophiopogon*, and ivies should go at the front. Contrast the hand-shaped foliage of the *Fatsia* with the white-edged blades of the *Miscanthus*. Spread white or gray pebbles as a mulch over the soil, and water the plants in well, ensuring they are not short of water while establishing. Aftercare is easy: cut down old herbaceous growth in late fall or spring, and watch out for slugs.



Hosta 'Francee'



Hebe salicifolia



Fatsia japonica



Phyllostachys nigra



Miscanthus sinensis 'Variegatus'



Ophiopogon planiscapus 'Nigrescens'



Formal front yard

Small front yards lend themselves to formal planting. Traditionally, these designs feature a low perimeter wall of clipped boxwood (*Buxus*) hedges in a simple shape, such as a square, filled with a mixture of brightly colored foliage and flowering plants, some tender, others perennials. There is often a central "dot plant," such as a *Cordyline*, to serve as a focal point. Any bare soil is then mulched with a layer of gravel. This helps to reduce weeding and keeps the garden looking neat.

Border basics

Size 5 x 5 ft (1.5 x 1.5 m)
Suits Boxwood hedges, bright tender perennials, colorful hardy plants
Soil Ideally, fertile, well drained, and not too dry
Site Small, formal situation, preferably with some sun

Shopping list

- 5 x *Pelargonium* (red)
- 3 x *Deschampsia flexuosa* 'Tatra Gold'
- 2 x *Phormium* 'Tom Thumb'
- 1 x *Penstemon digitalis* 'Husker Red'
- *Buxus sempervirens* (enough to make a border)
- 3 x *Spiraea japonica* 'White Gold'

Planting and aftercare

Dig over the site, removing any weeds, and add well-rotted organic matter, such as manure. Firm and level the soil with a rake. Plant the boxwood plants first, 6–8 in (15–20 cm) apart, to form the framework of your design. Then arrange the remaining plants in bands of color. The border will need regular upkeep to keep it looking immaculate. Deadhead the pelargonium throughout the season; in early summer, trim the boxwood and, if required, the spiraea. In spring, replace the tender pelargoniums and reduce the flowering stems of the penstemons.



Pelargonium (red)



Deschampsia flexuosa 'Tatra Gold'



Phormium 'Tom Thumb'



Penstemon digitalis 'Husker Red'



Buxus sempervirens



Spiraea japonica 'White Gold'



Mediterranean moods

Choose the sunniest spot in the garden, away from cold winds, and select plants reminiscent of Mediterranean vacations: irises, grasses, euphorbias, and evergreen shrubs, such as olearia. Add herbs, like rosemary or sage, and bright-flowered bulbs, such as alliums. Terra-cotta pots planted with more tender species, such as succulent agaves, will help reinforce the Mediterranean feel.

Border basics

Size 10 x 10 ft (3 x 3 m)

Suits Grasses, neat evergreen shrubs, irises, bulbs, herbs, succulents, semi-tender plants

Soil Any free-draining

Site Sunny and sheltered, ideally by a wall

Shopping list

- 3 x *Iris* 'Jane Phillips'
- 1 x *Olearia* x *haastii*
- 3 x *Euphorbia characias* subsp. *wulfenii*
- 5 x *Allium hollandicum* 'Purple Sensation'
- 1 x *Anemanthele lessoniana* (*Stipa arundinacea*)
- 1 x *Bergenia cordifolia*
- 2 x *Ballota pseudodictamnus*

Planting and aftercare

Dig over the soil, removing any stones and weeds, and add plenty of organic matter, such as manure. If the site is not well drained, dig in gravel. Set taller plants at the back of the border, at least 12 in (30 cm) from the base of the wall. Plant shrubs and perennials first; bulbs are best planted in drifts around the key plants later. The iris rhizomes should be near the soil surface, so that they are partially exposed. Mulch with gravel and water well.

Remove the flowering stems of irises after the blooms have faded. In spring, cut out the previous year's flowering stems of euphorbias as close to the base as possible, avoiding the toxic sap.





Iris 'Jane Phillips'

❄❄❄ 💧 ☼



Olearia x *haastii*

❄❄❄ 💧 ☼





Euphorbia characias subsp. *wulfenii*
❄❄❄ 💧 ☼



Allium hollandicum 'Purple Sensation' ❄❄❄ 💧 ☼



Anemanthele lessoniana
❄❄ 💧 ☼

Mixed herb tapestry

Well-planted herb borders should delight the senses: not only are they attractive to look at, but the aroma of foliage and flowers provides an extra element of interest, and some herbs can also be used to flavor food. Many have variegated or silver leaves, so they are still attractive when out of flower. Try also to include some evergreen herbs, such as lavender (*Lavandula*) or rosemary (*Rosmarinus*).

Border basics

Size 6 x 6 ft (2 x 2 m)
Suits Culinary herbs, such as thyme, oregano, marjoram, sage, chives, rosemary, and also those with more medicinal properties, such as lavender and feverfew
Soil Any well-drained, fairly poor soil
Site An open site in sun, but not too exposed to cold

Shopping list

- 10 x *Origanum vulgare* 'Polyphant'
- 5 x *Lavandula angustifolia* 'Twickel Purple' or *Salvia officinalis* 'Icterina'
- 10 x *Thymus doerfleri* 'Doone Valley'
- 10 x *Thymus* x *citriodorus*
- 10 x *Origanum vulgare* 'Aureum'

Planting and aftercare

Try adopting a formal pattern with the plants, as in the style of a simple knot garden. The plants can be positioned in rows or bands, where they will knit together well. The lavender is the tallest plant and should go at the back, or in the center if the bed is circular; the variegated sage *Salvia officinalis* 'Icterina' could be used as a culinary alternative. Next, plant contrasting bands of the smaller herbs.

A gravel mulch placed over the soil after planting helps to suppress weeds and keeps moisture away from the crowns of the plants.



Origanum vulgare 'Polyphant'
❄❄❄ 💧 ☼



Lavandula angustifolia 'Twickel Purple' ❄❄❄ 💧 ☼



Thymus doerfleri 'Doone Valley'
❄❄❄ 💧 ☼



Thymus x *citriodorus*
❄❄❄ 💧 ☼



Origanum vulgare 'Aureum'
❄❄❄ 💧 ☼

Alternative plant idea



Salvia officinalis 'Icterina'
❄❄ 💧 ☼



Fall elegance

A border designed for a fine fall scheme can make a great addition to the garden. After the dazzling displays of summer, this is a forgotten season in many gardens, and yet there are many plants that are at their best at this time. Certain grasses and various other late-performing perennials, such as *Sedum*, *Aster*, *Salvia*, *Kniphofia*, and *Verbena*, can be combined with the seedheads of plants that flowered in summer, perhaps set against the vivid autumnal hues of deciduous shrubs and trees.

Border basics

Size 10 x 10 ft (3 x 3 m)
Suits Late-flowering perennials, grasses, and plants with ornamental seedheads or berries
Soil Any well-drained, fertile soil
Site An open site in sun, not too exposed

Shopping list

- 3 x *Stipa gigantea*
- 7 x *Verbena bonariensis*
- 7 x *Sedum* 'Herbstfreude'
- 5 x *Calamagrostis brachytricha*
- 3 x *Perovskia* 'Blue Spire'

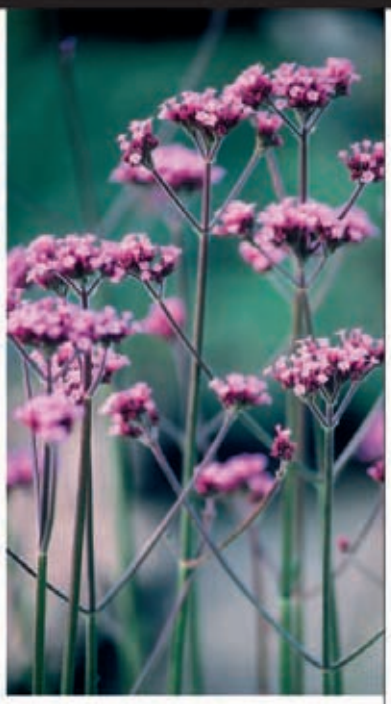
Planting and aftercare

For this scheme, it is better to plant in sweeps rather than groups for a more flowing effect. The *Stipa* is the tallest plant, so place it toward the back. In front, plant the dainty *Perovskia* and upright *Calamagrostis*. This grass flowers earlier in the season, but in fall the seedheads are an attractive rich brown. Allow the grass to mingle with the *Sedum*, best planted toward the front in a broad sweep, providing contrast and intense color. Dot the slender *Verbena* throughout because its transparent form provides no visual barrier.

Retain the seedheads of these plants for as long as possible, cutting down in spring before new growth begins.



Stipa gigantea



Verbena bonariensis



Sedum 'Herbstfreude'



Calamagrostis brachytricha



Winter blaze

Although winter is the season of snow and ice, there is still plenty to see in the garden if you include plants that provide seemingly unseasonal color. The stems of some deciduous shrubs, such as *Cornus* and *Salix*, are brightly hued, and the foliage of many conifers intensifies in color as low temperatures bite. A few plants produce showy flowers during this season, in particular winter heathers (*Erica*), but also bulbs such as snowdrops (*Galanthus*) and winter aconites (*Aconitum*).

Border basics

Size 10 x 10 ft (3 x 3 m)
Suits A range of winter-interest plants
Soil Reasonably well drained and not too dry
Site Somewhere open that catches the winter sun

Shopping list

- 1 x *Chamaecyparis lawsoniana* 'Elwoodii'
- 9 x *Erica* x *darleyensis* 'Archie Graham'
- 5 x *Cornus sanguinea* 'Winter Beauty'
- 1 x *Pinus sylvestris* Aurea Group
- 7 x white *Erica carnea*

Planting and aftercare

Position the *Chamaecyparis* toward the back of the border—it will serve as a fine foil for the brighter colors. The golden pine (*Pinus*) should also be toward the back, in front of the *Chamaecyparis*. Plant the *Cornus* in a drift, mostly in the middle of the border, edging toward the front. Underplant with the heathers, creating strokes of color. Do not intermingle the colors.

The best stem color from the *Cornus* is found on young growth, so after a couple of years, cut out one-third of old stems from each plant annually in spring. Trim the winter heathers with shears after they have flowered.



Chamaecyparis lawsoniana 'Elwoodii' ❄❄❄ ◑ ◊ ☼



Erica x *darleyensis* 'Archie Graham' ❄❄❄ ◑ ◊ ☼



Cornus sanguinea 'Winter Beauty' ❄❄❄ ◑ ☼



Pinus sylvestris Aurea Group ❄❄❄ ◑ ◊ ☼



Choosing a container

When selecting pots and containers from the wide range available at garden centers, there are some key factors to take into account before you buy. As well as choosing a style, shape, and color that suits your garden design, also consider the material from which the container is made, since each has its pros and cons.



Clay pots

Clay pots may be glazed or unglazed, colored or patterned, light or dark in color. Orange terra cotta brings a taste of the Mediterranean to the garden.

Advantages They are attractive to look at, and can make a long-lasting addition to the garden, often improving with age and wear. There is a clay pot for most situations, and they can be very good buys.

Disadvantages Many clay pots are not fully frost-proof and are prone to winter damage. They are also best avoided in exposed sites because they are easily broken. Fired clay is a porous material, so plants can dry out quickly, especially in summer, and moving these containers can be hard work since they are often heavy.



Metal containers

Containers made of metal may seem like a contemporary idea, but in fact some of the most desirable antique pots are lead, and suitable for a range of situations. Modern metal containers tend to be made of steel or galvanized aluminum and are simply styled, unlike lead planters, which feature more elaborate, classical designs.

Advantages By nature, metal containers are long-lasting, and can be heavy (especially lead ones), which makes them good for open sites. They can also be very stylish.

Disadvantages Metal containers can be expensive, particularly those made of lead; these are also exceptionally heavy. They also usually look out of place in an informal garden and may not suit some plants.



Wooden containers

Wood is a good material for a planter; it is soft and easily shaped, weathers well if treated with preservative, and suits a range of situations. It is also hard-wearing and can tolerate rough treatment.

Advantages Although fairly lightweight and therefore easily moved, wooden containers are strong and durable. They are also most attractive and a good choice for situations where large planters are required.

Disadvantages Good-quality wooden containers can be quite expensive, especially those suited to more formal sites. They also need regular treatment with preservative to keep them looking good. Make sure they are made from sustainably harvested lumber.



Stone containers

Pots and containers made of stone make beautiful ornamental planters. Granite containers can be used to give a Japanese feel, while old stone troughs suit alpines and other small plants.

Advantages Stone containers are very heavy, so not easily stolen or blown over, and long-lasting. Stone also looks good and gives a feel of permanence, especially once it has become colonized with mosses and lichens.

Disadvantages Genuine stone containers are very expensive, antique ones especially so, and you may feel that a concrete alternative is better value. The weight of stone must also be considered when transporting the pot and maneuvering it into place in the garden.



Synthetic pots

Plastic has long been used as a material for pots, and it may be disguised to look like clay, wood, or stone, although not always very convincingly. Increasingly, resins and other new materials are being used instead of plastic.

Advantages Synthetic pots are generally lightweight and easy to handle and transport. They tend to be tougher and more durable (and frost-resistant) than clay, and are far cheaper than stone or lead alternatives.

Disadvantages Synthetic pots lack the charm of traditional materials: an authentic stone, lead, or even clay planter feels more characterful than one made of plastic. Synthetic pots do not age well and may have a short life span. Being light, they are easily blown over.



Plant a colorful container

One of the simplest ways of injecting seasonal interest into your garden is to plant up a few pots. Follow these easy guidelines to help ensure that your displays are attractive and long-lasting.





1 Before you plant the container, add water-retaining crystals to the potting mix. These swell up once moist, and provide plants with an extra reservoir of water, which helps to ensure plants do not suffer in dry spells.



2 Arrange your selected plants in their original pots in the container to see how they look—this way, adjustments can be easily made. When you are satisfied, remove the plants from their pots and plant the container.



3 Fill around the plants with potting mix when they are in their final positions, leaving a 2-in (5-cm) gap between the top of the soil and the rim of the container to allow for easy watering and a gravel mulch.



4 Spread a ¾-in- (2-cm-) deep gravel mulch over the top of the soil to help to conserve moisture in summer, deter weeds, and prevent unsightly soil splash when watering. It also makes an attractive finish to the planting.

Spring selection

Few plants are a more welcome sight than spring-flowering bulbs, and most are easy to grow and care for. These versatile plants are wonderful for pots and window boxes or for planting out in the garden, and they can be treated as permanent plantings or simply discarded after flowering. A good selection should provide color over a long period, from the first snowdrops in late winter to the last tulips in early summer. Try planting the same types of bulbs together in pots and grouping them, or mix them.

Container basics

Size Approx. 6-in- (15-cm-) diameter terra-cotta pots
Suits Potted flowering bulbs
Potting mix Free-draining
Site Sunny, not too exposed

Shopping list

- 6 x *Hyacinthus orientalis* 'Ostara'
- 12 x *Narcissus* 'Sweetness'
- 10 x *Iris winogradowii*
- 12 x *Iris reticulata*
- 6 x *Iris* 'Katharine Hodgkin' or *Muscari armeniacum*

Planting and aftercare

Many spring bulbs are bought as bare, dry bulbs in fall, before they have come into active growth. It is important to choose firm, healthy bulbs and to plant them as soon as possible. Observe the correct planting depth for each kind of bulb, using free-draining multipurpose potting mix with plenty of crocks in the base of each pot. Keep the pots somewhere sheltered. As the bulbs begin to grow, water more freely.

Once the flowers have faded, either discard the bulbs or allow the foliage to yellow and wither. Bulbs may then be lifted, dried, and replanted in pots, or put in the garden in fall.



Hyacinthus orientalis 'Ostara'



Narcissus 'Sweetness'



Iris winogradowii



Iris reticulata



Iris 'Katharine Hodgkin'

Alternative plant



Muscari armeniacum



Sizzling tropics

A themed planting of subtropical species in a large pot will look dramatic and exotic until the first frost. Choose a mix of bold foliage and flowers, and try to use a limited palette of "hot colors" to tie in with the terra-cotta pot. Arrange the larger plants toward the center and back. The scheme will look most effective against a neutral background, where the textures and colors of the plants can be more easily appreciated.

Container basics

Size Approx. 24 x 24 in (60 x 60 cm) square terra-cotta pot or a similar-sized round one

Suits Subtropical plants with bold flowers and foliage

Potting mix Good-quality, multipurpose

Site Sheltered, sunny position

Shopping list

- 1 x *Canna* 'Musifolia'
- 3 x *Begonia fuchsioides*
- 3 x *Crocosmia* x *crocosmiiflora* 'Star of the East'
- 1 x *Pelargonium tomentosum*
- 1 x *Isoplexis canariensis*
- 2 x *Canna* (orange hybrid)

Planting and aftercare

Arrange the plants carefully in their pots before planting them to see how they will look in their final positions. The scented foliage of the pelargonium is best used spilling over the pot's edge. Place plenty of crocks in the base of the container before pouring in the potting mix. After planting, water well and keep in a greenhouse or cool, light area indoors before placing the pot outside once any danger of frost has passed. Feed the plants regularly during the summer and make sure the soil is kept moist. Deadhead the canna as the blooms fade to encourage further flowers. In fall, before the first frost, bring the pot under cover.



Canna 'Musifolia'



Begonia fuchsioides



Crocosmia x *crocosmiiflora* 'Star of the East'



Pelargonium tomentosum



Isoplexis canariensis



Canna (orange hybrid)



Color clash

For a dramatic and eye-catching container display, well-considered color clashes can produce the best results, although the careful use of texture and form is even more important in such schemes. Here, yellow variegated foliage contrasts harmoniously with the dark glazed pot, while the rich red mini petunias (*Calibrachoa*) clash. Touches of red in the linear foliage of the grass *Hakonechloa*, though, help to tie the planting together. The gently arching growth of the grass is complemented by the trailing periwinkle (*Vinca*), which mingles well with the petunias that spill over the sides of the pot.

Container basics

Size Approx. 16-in- (40-cm-) diameter glazed pot

Suits A mix of bedding plants and garden perennials

Potting mix Good-quality, multipurpose

Site Sheltered, sunny position

Shopping list

- 2 x *Hakonechloa macra* 'Aureola'
- 4 x *Calibrachoa* Million Bells Cherry
- 4 x *Calibrachoa* Million Bells Red
- 4 x *Vinca minor* 'Illumination'

Planting and aftercare

Place a good layer of crocks in the base of the pot for drainage, and add the soil. Position the grass centrally and then plant the *Vinca* and mini petunias around the outside. The petunias are frost-tender, but they will flower for a long season in a sunny position, provided they are kept well fed and watered. In a more shaded spot, the petunias can be replaced by a red busy Lizzie (*Impatiens*) or a bedding begonia. After frost has browned the bedding, surviving plants can be planted out in the garden, or kept in the pot and used again the following year.



Hakonechloa macra 'Aureola'



Calibrachoa Million Bells Cherry



Calibrachoa Million Bells Red



Vinca minor 'Illumination'



Fire and ice

A striking combination of silvery blue foliage and flame red flowers gives this fall-interest container great appeal. The flower power is provided by bedding cyclamen, which often proves surprisingly hardy in a sheltered situation, and should flower well from fall until the first really hard frost. White crocuses could continue the show in spring. Bright silver *Senecio*, tufts of the blue grass *Festuca glauca*, and an upright juniper complete the display. A matching pair of these planted pots would look particularly striking on either side of a doorway.

Container basics

Size Approx. 16-in- (40-cm-) diameter terra-cotta pot

Suits Evergreens and winter bedding plants

Potting mix Good-quality, multipurpose

Site Sheltered spot in semi-shade

Shopping list

- 1 x *Juniperus chinensis* 'Stricta'
- 2 x *Festuca glauca* 'Elijah Blue'
- 5 x *Senecio cineraria*
- 3 x *Cyclamen hederifolium*

Planting and aftercare

Place a layer of crocks in the pot and fill three-quarters full with potting mix. Plant the juniper centrally toward the back of the pot and use the grasses to help soften the edges. The cyclamen and *Senecio* can be mingled at the front. (If you are including crocuses, plant them now; they will appear in spring, replacing any cyclamen killed by sustained hard frost.) Top off the pot with potting mix, water well, and place in a sheltered spot in good light. Keep the soil moist but not wet, and deadhead the cyclamen during the winter to prolong the displays. In late spring, the plants can be planted out in the garden, or transferred to a larger container.



Juniperus chinensis 'Stricta'



Senecio cineraria



Cyclamen hederifolium



Festuca glauca 'Elijah Blue'



Winter perfume

This attractive display provides colorful winter cheer and a delicious spicy scent, which comes from the *Sarcococca confusa*, a neat evergreen shrub with little white blooms. While not particularly showy, they scent the air for several weeks. Flower and foliage color is provided by winter pansies (*Viola*), a variegated standard *Euonymus*, and ivy (*Hedera*) to soften the rim of the barrel. You could also add primroses (*Primula vulgaris*), which flower into spring.

Container basics

Size Approx. 24-in- (60-cm-) diameter wooden half-barrel

Suits Winter bedding and evergreen shrubs

Potting mix Multipurpose with added compost

Site Sunny, sheltered spot by a doorway

Shopping list

- 5 x *Hedera helix* 'Glacier'
- 5 x yellow winter pansies
- 5 x pale yellow winter pansies or 3 x double yellow primroses
- 3 x *Sarcococca confusa*
- 1 x *Euonymus fortunei* Blondy (standard-trained)

Planting and aftercare

Place crocks at the bottom of the barrel and fill three-quarters full with potting mix. Arrange the plants with the *Euonymus* in the middle, underplanted with the *Sarcococca*, the ivies over the edges of the barrel, and the pansies and primroses in between. Fill in around the plants with potting mix. Water well and keep moist. Position the container where the perfume of the *Sarcococca* will be enjoyed. Remove faded blooms as the season progresses, and any plain green shoots on the *Euonymus*. In summer, replace the bedding with summer flowers, such as busy Lizzies or begonias.



Hedera helix 'Glacier'



Yellow winter pansies



Pale yellow winter pansies



Sarcococca confusa



Euonymus fortunei Blondy

Alternative plant idea



Primula vulgaris 'Double Sulphur'



Design ideas for easy-care gardens

There are a great many reasons why you may want to make your yard easier and less time-consuming to maintain.

Happily, there are numerous strategies and solutions that can be employed without sacrificing aesthetics.



Pictures clockwise from left

Outdoor gallery The planting of a garden can be quite sparse if each specimen is chosen and sited with care, rather like an arrangement of sculptures. With a simple, uncluttered backdrop, this approach creates an opportunity to really appreciate the form and texture of the plants in your collection. Gravel laid over a weed-suppressing membrane provides a foil for the plants, and to keep the design interesting, aggregates can be enlivened with decorative paving, or cobbles and boulders. In this garden, large rocks anchor the planting, and treated timbers, laid like stepping-stones, direct the eye to a circular mosaic feature with a striking contemporary container providing a focus in the center. Alternatively, you could use a self-contained water feature, such as a bubbling millstone.

Dining room Decking brings a roomlike quality and can be used to create a stylish outdoor dining area. This is especially valuable where space indoors is at a premium. To create a visually exciting design that requires very little upkeep, make sure the backdrop and planting around the deck are as simple as possible. A few bold color highlights and nighttime illumination will add designer sparkle.

Simple division Larger gardens designed for minimum maintenance are often best divided into a series of compartments. These can be partially screened from one another, or left open to enjoy the sense of space. To give each section its own character, and to add interest, try using contrasting landscape materials—on flat surfaces you can introduce changes in level, such as a raised deck or beds, or a sunken seating area. With a limited planting palette, it is important to be creative with flooring detail, and to include plenty of evergreens, such as the grasses (*Stipa tenuissima*) and sedges (*Carex*) used here.





Design ideas for easy-care gardens *continued*

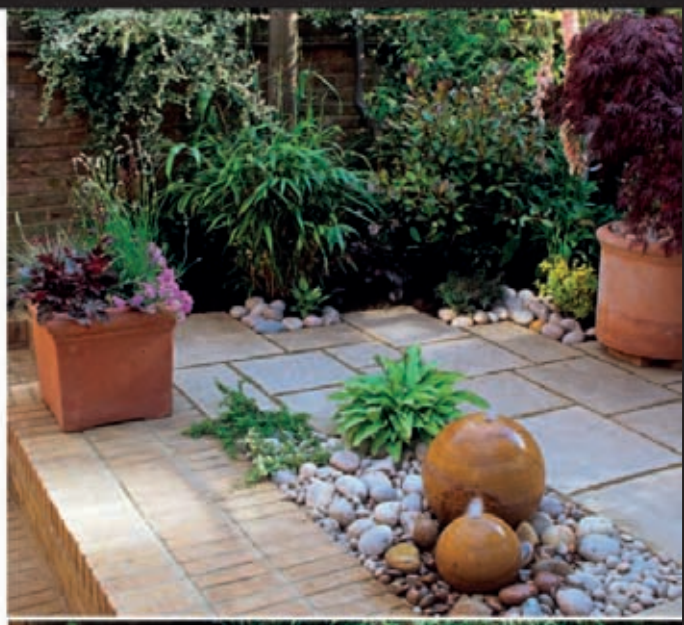
Pictures clockwise from top left

Paved patio Small, enclosed spaces are perfect for paving—a low-maintenance, relatively weed-free alternative to grass. By planting in raised beds, narrow borders, and pots, you can maintain a range of plants that would satisfy even the most avid gardener. Spend time designing your garden, building in practical requirements as well as incorporating different textures and patterns to create interest. Here, cobbles and a ceramic water feature provide a focus, with hostas and bamboo adding an Asian note.

Mediterranean garden This swirling stuccoed wall, painted a dusty terra-cotta, suggests a garden built in a sunny climate. Slender Italian cypress, an old oil jar, and ironwork furniture strengthen the Mediterranean flavor. The wall is the right height to act as impromptu seating and, adding to the ambience, the air is filled with perfume from the white lilies, pink roses, and aromatic herbs.

Space for children Although children enjoy playing on lawns, other surfaces are more versatile. Little ones will enjoy a sandbox (covered when not in use), and varying the flooring materials and incorporating changes in level can create opportunities for play. A splinter-free deck suits bare feet and the level surface is ideal for a variety of toys and activities. Choose robust plants, such as the phormium, grasses, and bamboos in this child-friendly garden.

Raised beds As well as providing easy-access planting spaces, raised beds are design features in their own right. They also offer casual seating and welcome changes in level in otherwise flat, featureless spaces. This bed, with its curved dry-stone walling effect, provides ideal, sharply-drained conditions for a wide range of hardy alpines.









Formal design

An ordered or symmetrical garden, with a combination of simple geometric shapes, inspires a feeling of calm. The style is adaptable, and it is easy to create stunning vistas and dramatic focal points.





Pictures clockwise from top left

Creating a focus The elements of this charming little garden are simple and unfussy, yet because of the strong central axis guiding the eye down the narrow pathway, the effect is quite theatrical. Tall *Verbena bonariensis* are neatly enclosed by clipped dwarf boxwood hedging, which, being evergreen, provides a strong architectural framework, even in the depths of winter. A traditional brick path opens out into a circular paving feature with a large Greek pot at its center, but this could be replaced by a pebble mosaic or an eye-catching piece of sculpture.

Elegant dining Although most often associated with grand historic properties, a formal touch, utilizing symmetry, works in a variety of situations and can make a previously ordinary space look stunning. Here, French windows open out onto a raised deck used for dining. Elevated views of the garden are framed by tall, stylish containers filled with lavender, and a grapevine-covered arbor. The formality continues with matching steps, clipped boxwood edging, and twin potted marguerites.

Contemporary twist There's no reason why you can't take elements of Renaissance gardens and use them to add style to a contemporary space. Here, tall perennials (*Miscanthus* and *Rudbeckia*) are contained by low evergreen hedging—just like a modern-day parterre—and clipped topiary in matching terra-cotta pots makes a stylish statement. A rill or narrow canal set into the deck would also work well.

Mirror image This study in symmetry and minimalism has created a garden that is extremely easy to maintain. Simply planted, the design succeeds by clever stage-setting. The onlooker's eye is drawn to the water curtain sculpture by a line of cube-shaped box topiaries running along the central axis. Meanwhile, the two formal white containers, matching raised beds planted with bamboo, and the arching tree branches frame the view perfectly. Keep the surfaces immaculate to avoid visual distractions.





Contemporary creations

Modern minimalism has much to offer busy garden owners. Simple layouts, easily maintained hard landscaping, and color and interest that don't rely solely on planting are useful elements often exploited by contemporary designers.











Pictures clockwise from far left

Color impact Use bold shades, like purple or red, to enhance contemporary designs and create exciting backdrops. Here, architectural foliage plants, including phormium and eucalyptus, are all the more striking against the painted fence. A stuccoed wall could also act as a modern minimalist canvas, if painted with masonry paint.

Sculptural focus The gleaming white spiral of this art installation stands out dramatically against the dark uncluttered backdrop and restrained planting plan. Alternative sculptural elements, such as a large container or fountain, could be used to create a focal point strong enough to carry the simple design.

Restrained planting While gardens often rely on colorful flowers and foliage for interest, you can still create an attractive outdoor space using a limited planting palette. This ground plan is well defined, and strengthened by innovative flooring and dividing walls. Only a few of the rectangular compartments contain plants—many are filled with water and bridged by decking walkways.

Novel materials You can achieve contemporary effects with high-tech materials. Consider acrylic plastic panels, or polished and galvanized metal sheeting for facing walls and edging beds, and metal grids for flooring. Here, corrugated metal contains a grass-filled border.

Simple composition Taking inspiration from Zen gardens, this simple but effective layout, with a background of white stone chips and black trellises, features a single phormium surrounded by carefully selected rocks and a black glazed sphere.

Havens for wildlife

Low-maintenance gardens can be surprisingly wildlife-friendly. Many easy-care plants attract bees and butterflies, and shrubs and trees with ornamental fruits offer a feast for birds.





Pictures clockwise from top left

Watering hole Providing a safe vantage point to drink and bathe, a birdbath can become a hive of activity for birds; site conveniently, as you'll need to top it off regularly. To avoid problems with cats, plant around the base with low ground cover. Here, blue fescues (*Festuca*), houseleeks (*Sempervivum*), and sedums are used. A shallow-sided pebble pool would also attract amphibians and dragonflies.

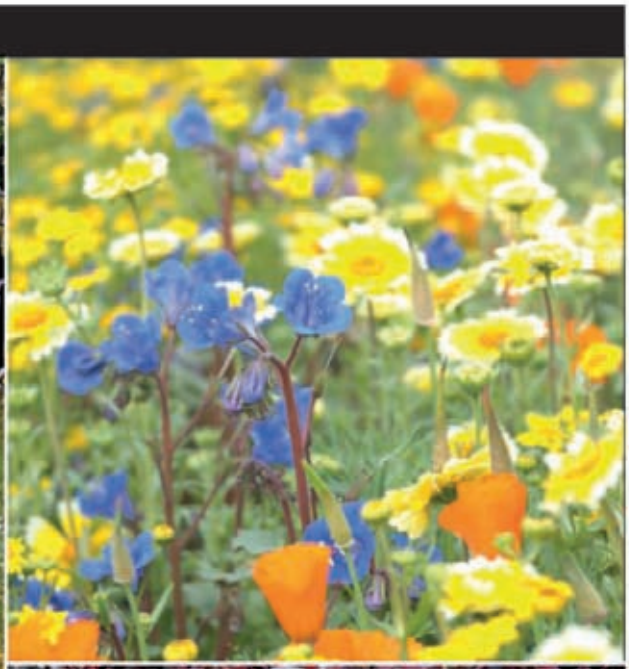
Carefree meadow One way to reduce the need for regular mowing in a large garden, while increasing wildlife potential, is to convert sections of formal lawn into wildflower meadows. On poor, sandy soil, you can establish a meadow using wildflower plugs and bulbs suitable for naturalizing. More reliable results are achieved by removing sod with a sod-cutting machine and then re-sowing with a perennial wildflower mix.

Insect attractors Beneficial hoverflies seek out single-flowered annuals, such as *Eschscholzia* and *Limnanthes*, and bees love blue flowers like this California bluebell (*Phacelia campanularia*). *Verbena bonariensis* and *Buddleja davidii* are magnets for bees and butterflies. For the first insects of the season, plant sunny gravel or raised beds with spring alpines—alyssum, arabis, aubrieta, heathers, grape hyacinth (*Muscari*), and crocus.

Bird cover Large evergreen and deciduous shrubs, dense hedges, and trees are vital for birds. They not only need safe nesting and nighttime roosting sites, but also places to shelter during bad weather and to escape airborne predators. Without cover nearby, birds are nervous about entering a garden, even one with feeders.

Berry banquet Provide a wide range of fruiting and berrying plants, with some ripening in late summer and others ready for harvest well into winter. This long-lasting buffet will cater to local birds as well as visiting migrants. Low ground-cover plants such as *Cotoneaster salicifolius* 'Gnom' (*illustrated*), wall shrubs like pyracantha, roses with large colorful hips, and small ornamental trees, such as rowans (*Sorbus*) and crab apples (*Malus*), are ideal.







Courtyard gardens

Textures and colors are viewed close up in these intimate spaces, so choose materials and plants for maximum effect. Also include some shade and water, as well as lighting for evenings outside.





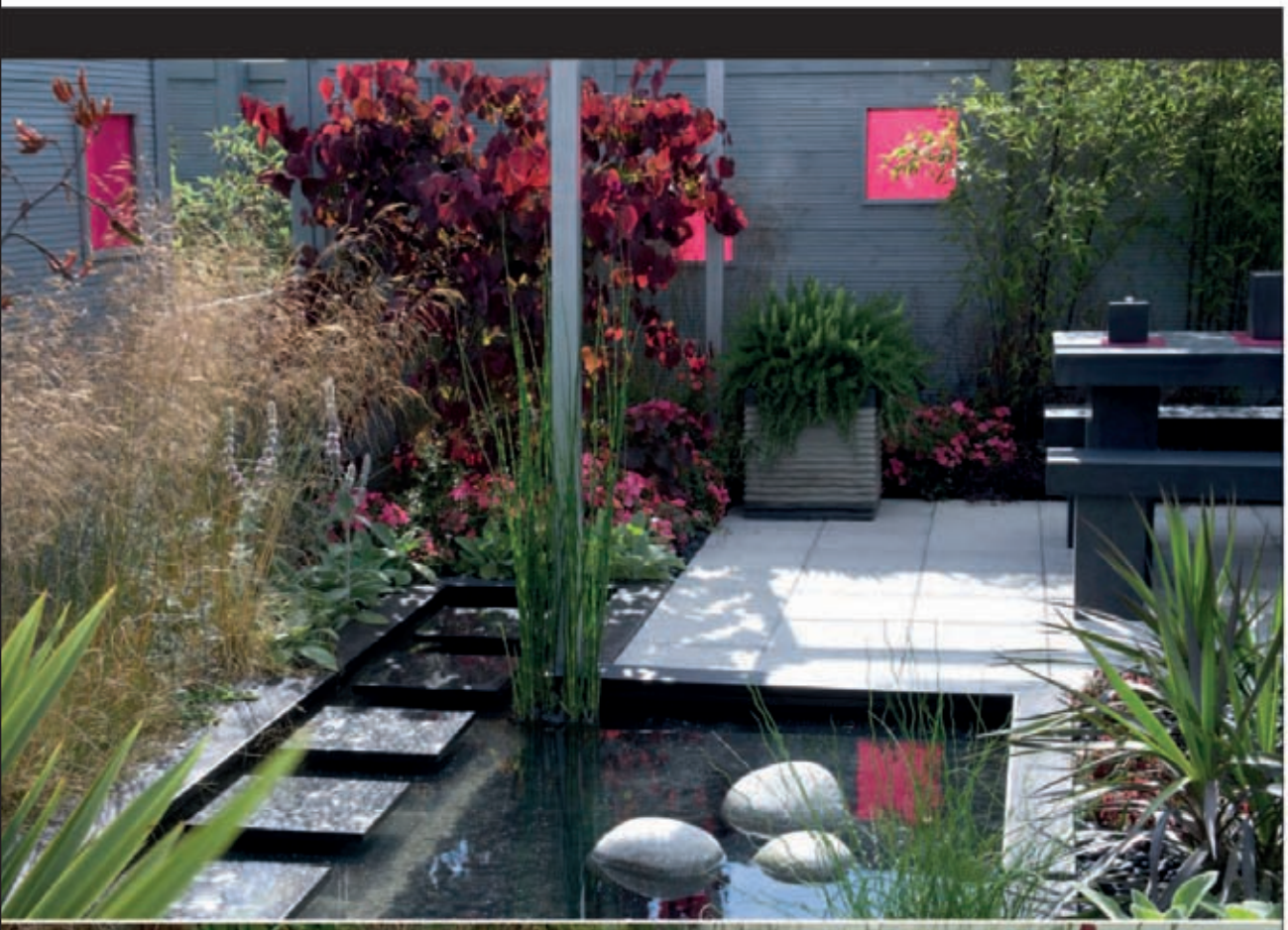
Pictures clockwise from top left

Big, bold pots Some outdoor spaces are completely paved, but you can grow almost any plant in a container—provided it is big enough—including small trees, elegant bamboos and grasses, a wide range of shrubs and climbers, as well as perennials, bulbs, and ferns. This pot contains *Nandina domestica*, purple cordyline, heuchera, and trailing ivy. Evergreens help the garden look good all year, and courtyards often have a sheltered microclimate, allowing less hardy species to be grown. Install automatic irrigation to make light work of watering.

Tranquil oasis This striking, contemporary walled garden has a Moorish feel. The lush planting, inspired by a rich purple and cerise color palette, features a glowing *Cercis canadensis* 'Forest Pansy' in the corner, and a large formal pool with "floating" stepping-stones. The arbor-covered, paved terrace juts out over the surface, taking you right to the water's edge.

Hot property Courtyards can feel gloomy if surrounded by high walls, but you can lift the atmosphere and create more light by applying color (on taller walls, just paint to a line above the ground-floor windows). Here, a vibrant orange has been used on a curved wall, contrasting with beds of Mediterranean herbs, perennials, and grasses. Where shade is a problem, whitewashed walls may appear to be the answer, but these need frequent touching up and white can seem harsh in a cool climate; instead, try light pink, pale green, watery blue, or pearly gray. Also consider wall-mounted mirrors or reflective metal panels, murals and *trompe l'oeil* (illusory 3-D effects) or, for a historic look, decorative trellis panels.

Garden café Courtyards can be transformed into an extra room for your house, and an *al fresco* dining room or outdoor kitchen can be used in fine weather at any time of year. Raise or sink the dining area to give it definition, and construct screens with giant pots or raised beds filled with architectural evergreens, like the cordyline and clipped boxwood balls in this stylish garden.





New-wave planting

This impressionistic style of gardening, sometimes known as prairie planting, uses harmonious combinations of herbaceous perennials and ornamental grasses to create naturalistic and long-lasting displays.





Pictures clockwise from top left

Planting philosophy Choose easy-care perennials that don't need deadheading, staking, or frequent division. Plants that have everlasting flowers or sculptural seedheads in fall and winter are particularly useful; most grasses, even deciduous types, retain foliage and diaphanous seedheads through winter. For the prairie look, plant swaths of single cultivars and punctuate with isolated clusters. Soften the effect of heavier flower and foliage forms by using airy flower stems and billowing grasses, and vary the height of plants to create interesting undulations. Here, crimson astrantia rise above a ribbon of erigeron interspersed by tussocks of *Stipa tenuissima*.

Stylized nature Planted *en masse*, color-restricted displays of flowering perennials and grasses produce a stylized, contemporary version of a meadow. Here, raised beds lift the planting to create a feeling of enclosure around this outdoor dining area. An elegant mixture of tall miscanthus grasses and *Verbena bonariensis* opens up to reveal blocks of lavender on the opposite side.

Lingering effects From midsummer onward, *Rudbeckia fulgida*, as well as plants like the heleniums and achilleas seen growing here, put on a long-lasting show. Interspersed with hardy grasses—such as calamagrostis, miscanthus, panicum and stipa—they knit together seamlessly, covering the ground and preventing weed growth. Many of the grasses also flower in late summer, adding to the display, and the foliage fades to biscuit or develops red and purple hues as fall approaches. It is only necessary to cut back hard when growth begins again in spring.

Grassy retreat The planting in this gravel garden is relaxed and informal—the seating area is completely cocooned by billowing grasses, and narrow pathways wind lazily through the subtle planting. Although there are few colored blooms, this garden will change throughout the year and will look magical with a dusting of frost.





Benefits of a low-maintenance garden

With adjustments to your existing yard, or strategic planning when building from scratch, you can enjoy a beautiful garden even if you have little time or energy to care for it. Most high-maintenance plants and plans have low-maintenance alternatives, and many routine jobs can be omitted altogether.

Who needs a low-maintenance garden?

We simply do not have as much time as we used to, and yet the garden is increasingly seen as a sanctuary and an antidote to modern living. Whether you are pursuing a career, working odd shifts, spending hours commuting, or raising a young family, you will need to find a way to manage your garden more easily.

New gardeners may lack confidence in their abilities and want to start simply, and some homeowners are not particularly interested in the practical side of gardening, yet still appreciate and desire an attractive outdoor space. Older gardeners may find they no longer have the physical strength and energy to cultivate in the way they used to or, adopting a more carefree lifestyle, might be too busy traveling to garden regularly. And if you are a landlord with rental properties, you may only be able to visit them a few times a year.



Creative design and planting will ensure that ultra-easy-care gardens like this urban yard are attractive, practical, and never boring.



With easy-care gardening strategies in place, you can cut down on regular or seasonal chores like raking leaves and lawn maintenance.

How much time do you have?

When designing your yard, first think about how frequently you will have time to maintain it.

Weekends If you have a few hours on the weekend, you may only have time to mow the lawn, do a little deadheading and tidying up, and perhaps do some hand-weeding, hoeing, or hedge-trimming. Drought-tolerant shrubs and flowers in pots will survive with weekly waterings.

Once a month Lawns are not a good idea if you can only tackle gardening tasks once a month. Instead, replace them with paving, decking, or gravel. Reduce deadheading and pruning with a selection of easy-care plants, and install an automatic watering system.

A few times a year Gardening only once in a while restricts your options, so choose a combination of low-maintenance plants and hard landscaping. You can then limit jobs to tidying up borders, cutting back old growth on perennials in late winter, and occasionally pruning overgrown trees and shrubs.

Time-saving tips



Watering Select drought-tolerant specimens, and plant in fall or spring to cut down the need to water while the roots are establishing. Set up pots with automatic irrigation.



Fertilizing Mulch with manure in late winter to keep the soil fertile. Once or twice a year, fertilize flowering plants, including those in containers, using a slow-release fertilizer.



Deadheading Choose plants with ornamental seedheads and avoid any that need deadheading to keep them blooming. Tidy up ground-cover perennials and lavenders with shears.



Weeding Cover the ground with a weed-suppressing fabric camouflaged with gravel. Spray weeds with systemic weedkiller to kill the roots. Avoid soil disturbance and self-seeding plants.



Mowing Choose an easy-care grass seed mix. Reduce the lawn size and buy an efficient mower. Install a brick mowing strip next to borders and walls to eliminate edging.



Pruning Choose evergreens, as they rarely need pruning, and plants that only need one trim per year, such as *Buddleja davidii*. Avoid overly vigorous shrubs and allow plants room to grow.

Low- and high-maintenance ingredients

Choose the plants and materials in your garden carefully to minimize the workload.

Easy-care gardens

Paved or decked surfaces are easy to keep clean and weed-free, and surrounding your plants with hard landscaping, or growing them in raised beds, keeps them within bounds; you can also carry out most jobs in nearly any weather. Although there is an excellent selection of low-maintenance flowering shrubs and perennials, choosing specimens for their architectural qualities, foliage color, and texture, rather than for their blooms, will ensure that the planting is interesting year-round.





Hardy bulbs Dwarf and low-growing hardy bulbs, like crocus, scillas, and small daffodils, offer a maintenance-free spring show. For summer, plant alliums and low-growing lilies that do not need staking. Dying down gracefully, these bulbs are left in the ground to come up year after year.



Drought-busters Plants like these houseleeks do not need watering at all. If you live in a dry region, or the garden has a hot, sunny exposure and free-draining soil, focus on drought-tolerant plants, such as succulents or silver-leaved varieties. Avoid pots or consider installing automatic irrigation.

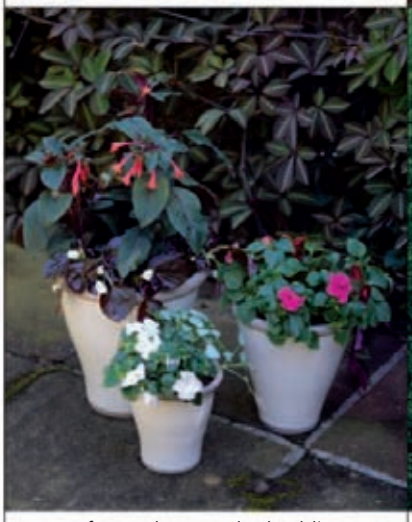


Plant-free features Bringing color into the garden with painted walls or trellises reduces the need for bright bedding displays. Decorative paving elements, such as pebble mosaics, add textural interest, while sculpture and stylish outdoor furniture provide maintenance-free highlights.

Labor-intensive gardens

Manicured lawns require a lot of upkeep: mowing and edging, weeding and feeding, moss-killing, scarifying to remove dead material, aerating to improve drainage, and sweeping up leaves in fall. Of course, a roughly maintained family lawn, or one where clover and other attractive "weeds" are allowed to grow, needs much less attention. Traditional borders full of blooms, and backed by flower-festooned walls and fences, look spectacular in summer, but it is difficult to keep on top of deadheading, staking, weeding, and watering, not to mention tying climbers and wall shrubs onto their supports. Self-seeding can also become a time-consuming problem.





Pots If you plant tender bedding plants, annual flowers, and bulbs in containers, you are committing yourself to time-consuming tidying up as well as daily watering in hot weather, and regular fertilizing to keep plants healthy. At the end of each season, displays have to be replanted.



Fast-growing hedge One of the most challenging tasks is staying on top of quick-growing plants, like privet and tall conifers. Several cuts a year are required to maintain a neat profile and control height and spread, and removing the clippings can also be laborious.



Tender plants A recent trend in patio gardening has seen an increase in the use of exotics, such as bananas, tree ferns, cannas, and agaves. These plants are too large and expensive to discard at the end of summer, but need to be fully protected from frost *in situ* or in a greenhouse.

Assessing your site

Look critically at your yard before carrying out any major changes. Weigh up the pros and cons of features before removing them, and remember that mature, established plants may need less maintenance than new ones.



Which way does your yard face? Work out where the sun rises (east) and sets (west). Eastern exposures are sunny in the morning—winter and spring-flowering shrubs are vulnerable to frost here. West-facing walls and fences have sun in the afternoon and evening—ideal for relaxing after work. Areas in sun for much of the day are south-facing, and shady, cool spots opposite have a northern exposure.

What do you need?

Make a list of the various activities and areas planned for your yard, including places for growing plants, supporting wildlife, relaxing, cooking, and dining *al fresco*. Bear in mind factors like sun and shade, drainage, shelter from wind, and proximity to water and electrical outlets. Don't forget practicalities like easy access to garbage cans or recycling bins and compost piles, as well as storage space for garden tools and furniture.



Guinea pigs and rabbits like to graze and run on grass; lawns also benefit songbirds.



Make children's gardens versatile, and easy to adapt when they tire of play equipment.



Areas for outdoor entertaining might include a grill, a sunken fire pit, or a gazebo.

Understanding climate

You can live in an area that suffers from early and late frosts or that's battered by winds, while enjoying milder conditions in your garden. South- and west-facing yards are suntraps; walls and paving absorb daytime heat and radiate it back at night, keeping surrounding areas frost-free. Trees and hedges act as buffers against wind but, conversely, buildings can cause damaging turbulence. Such local variations are known as microclimates.



As sunny walls radiate heat, tender plants like this ceanothus can thrive in frosty regions.



Hedges and shrub borders slow the wind and provide shelter for plants and people.



Cold air pools at the bottom of slopes, and plants here are more vulnerable to frost.

Boundaries and garden dividers

The style and fabric of the elements you choose to enclose or separate parts of your yard have a major impact on the overall effect of the garden. Boundary materials frequently act as a foil, but can also make a bold statement.



Wooden fence Choose the highest-quality fencing that you can afford for long-lasting results. Pressure-treated posts are easier to replace and last longer if placed into metal sockets rather than directly into concrete.



Trellis A decorative screening material with panels in various styles, a trellis may also include shaped pieces for special features. Letting in more light but offering less privacy than solid paneling, it is best for internal divisions.



Willow or hazel hurdles These hand-woven panels are perfect for cottage-style gardens. For a contemporary look, attach to aluminum posts or a solid lumber frame. Panels last for about eight years.



Stucco wall Cinder-block walls are quicker and cheaper to build than brick and, when stuccoed, can be painted in a range of colors to create a smart and stylish finish. Stucco is often used for contemporary designs.



Brick wall Garden walls are decorative and practical, and frostproof bricks are available in a range of styles to match adjacent buildings. Antique or reclaimed bricks create the illusion of age and are ideal for historic gardens.

Green dividers

Fences and walls provide opportunities to grow a wide variety of climbers and wall shrubs, and the plants help to camouflage boundary imperfections. Also, living screens of tall ornamental grasses, bamboos, shrubs, and trees offer exciting alternatives to formal hedging.



Bamboo screen Some bamboos make beautiful evergreen screens, which suit both Asian-style and contemporary yards. Non-invasive, clump-forming cultivars of *Phyllostachys* and *Fargesia* are ideal, their upright canes often developing attractive tints and banding. Plant a row in moisture-retentive ground, allowing them room to spread sideways. To control the width of the screen, remove unwanted bamboo shoots at ground level in late spring. Periodically thin out some mature canes, and remove leafy growth from the lower half of the screen.



Climbers There are only a few climbers that are self-clinging and do not require wires or trellis. These include *Hydrangea anomala* subsp. *petiolaris* (*above*) and ivy. Be sure to choose the right plant for the site and soil type—some prefer cool shade, while others bloom best on a sunny wall. Also consider the plant's ultimate height and vigor, to avoid problems in the future.



Yew hedge When clipped formally, this dark evergreen forms a dense wall or plain backdrop for borders. Relatively slow-growing, it can eventually be trained into arches and other pieces of green architecture. Yew is long-lived and regenerates from old wood if pruned hard. Although shade-tolerant, hedges are best cut wide at the base and narrow at the top, so that light falls evenly on the foliage.



Tree and shrub divide Ideal for protecting windswept gardens, a boundary of trees and shrubs makes a particularly effective shelterbelt. Mix different shapes, textures, and colors, including flowering and berrying types, for maximum interest, and prune to control size.



Living willow screen In heavy clay soil, willow stems pushed into the ground will root easily. Setting these hardwood cuttings at an angle forms the beginning of a diamond lattice. Simply hook the willow stems under and over one another to the desired height, and then weave the excess at right angles to secure the upper edge of the screen. Trim the stems as necessary.



Fedge This is a cross between a fence and a hedge, and is an ingenious way to camouflage ugly chain-link fencing. It is best to use a plain green ivy for rapid cover and to produce a slim, dense, hedgelike structure. Plant pots of young, vigorous ivies at the base of the screen, and weave the shoots in and out as they grow. Once the fence is covered, trim the ivy using hand shears.

Selecting landscape materials

The natural or synthetic products you choose, and the patterns and designs you employ, make a big difference to the overall look of the garden. Other considerations include the cost of materials, ease of laying or installation, and long-term durability.

Granite pavers These hard-wearing cubes of granite are ideal for driveways and areas in heavy use, and can be arranged to make very attractive circular, curving, or interlocking paving patterns as well as the straightforward grid design illustrated. Made of natural stone, these paving blocks suit historic properties and country residences, but they can also be used in a variety of situations to add textural interest to areas paved with slabs. Granite pavers are expensive but concrete substitutes are available.



Using contractors When hiring someone to carry out hard landscaping work, be prepared to show them a scale drawing or at least mark out the areas to be paved or decked to avoid confusion. Get a number of quotes and, especially if the contractor hasn't been personally recommended, ask to see examples of their work so that you can do your own quality check. After considering your ideas, contractors may help you select suitable materials and provide paving samples; also discuss clearing and preparing the ground, waste removal, drainage requirements, electrical wiring, and paving patterns and designs. Once you are happy with a quote, draw up a formal agreement for the contractor to sign, stating exactly what you expect them to do for the price, with start and end dates.



Natural stone Ethically sourced sandstone, limestone, and granite paving reveals subtle colors when wet and does not chip or fade, but it tends to be thicker, heavier, and less uniform, and is more expensive than concrete reproductions. Consider hiring an experienced paving contractor.



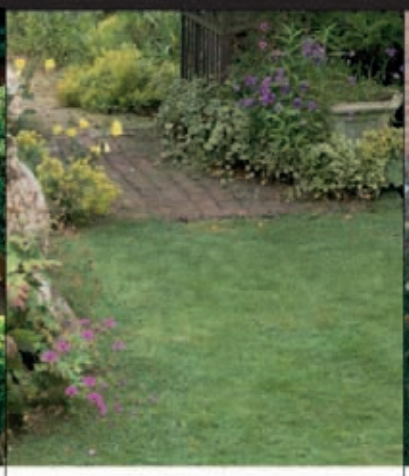
Concrete paving There is a wide range of concrete paving available, from plain, contemporary designs to textured stone reproductions and modular paving sets. Quality varies, and some styles are thicker and more hardwearing with better resistance to chipping or fading in sunlight.



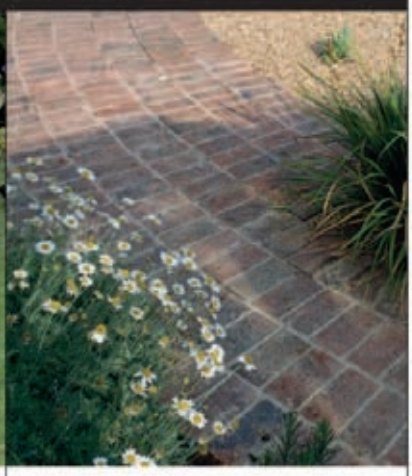
Woodstone A convincing substitute for wooden landscape timbers, the concrete is imprinted with the texture of weathered, reclaimed wood and suits country or cottage garden situations. It can also be used for steps, stepping stones in gravel, and to construct low raised flower beds.



Wooden decking Decking is warm underfoot and dries rapidly after rain. Do not use in shady areas as it quickly develops slippery algae. Off-the-shelf kits are available from do-it-yourself stores, but hire a specialist for larger, more complex areas. Western red cedar is naturally rot-resistant.



Sod New gardens are often laid with sod prior to implementing a design. A well-maintained lawn makes an attractive foil for borders and contrasts well with hard landscaping. Lawns are important for many birds and provide a safe play surface for children. Install a mowing edge.



Bricks Frostproof bricks, engineering bricks, and pavers can be laid in a wide variety of patterns, such as curving shapes and circular designs; they also add texture to areas paved with slabs. Bricks come in different shades and styles, including antique effects that suit older properties.



Cobbles Pebbles and cobbles of different colors and grades can be used with other materials, such as slate shards and tile fragments, to create paving mosaics like the circular feature above. Simple designs are not difficult to make, as the pebbles are bedded into a dry mortar.



Gravel This versatile and inexpensive material comes in many different grades and colors, allowing it to blend with other landscape materials. Laid over a permeable membrane, it's an easy way to create pathways and patios. Contain gravel to separate it from soil using slightly raised edgings.



Decorative aggregates Slate chips (*above*) are one of several stone aggregates now available for garden landscapes. More dramatic or contemporary effects can be created with colored stone chips and glass chips. Lay as for gravel, over a permeable membrane.

Designing with different materials

Hard surfaces act as a framework around which plants can grow and mature. The chosen material, and the style in which it is laid, can enhance the design of your outdoor space.



Decking jetty This substantial wooden platform hangs over the pool below, allowing close access to the water. The clean lines and restrained planting combine to create an open expanse of warm wood and tranquil water.



Basketweave bricks This garden is paved in a traditional design that suits older properties and has cottage-garden appeal. The weathered terra-cotta coloring and intricately textured surface of the bricks give an aged quality.



Sleek slabs Smooth, simple concrete pavers laid in a uniform row or geometric grid create a contemporary feel. This minimalist style of paving helps to emphasize the planting as well as architectural and design features.



Vintage stone Reclaimed stone from architectural salvage companies gives a garden a feeling of permanence. The worn and weathered surface of the stone adds character, perfect for this formal pool terrace edged in boxwood.



Zen gravel garden Gravel is used here to emulate a dry Zen garden or *karesansui.* The rugged boulders and simple evergreen plantings represent islands in a sea or lake, reflecting traditional Japanese designs.

Spring mix

This woodland carpet could be recreated under the dappled shade of deciduous trees or large shrubs. The planting reaches its peak in early spring when the snowdrops open and the bronze-pink fronds of the maidenhair fern (*Adiantum*) unfurl. The marbled arum foliage makes a lovely foil for various forms of hellebore that flower through winter; select these in bloom, as catalog descriptions can be misleading. The colored petals are long-lasting and the nodding flowers of *H. orientalis* subsp. *guttatus* have speckled throats.

Border basics

Size 5 x 5 ft (1.5 x 1.5 m)
Suits Shade-loving woodland plants that flower in late winter or early spring
Soil Moist, with a deep organic mulch
Site Under trees or north-facing border

Shopping list

- 7 x *Adiantum venustum*
- 9 x *Arum italicum* subsp. *italicum* 'Marmoratum'
- 5 x *Helleborus* x *hybridus* cultivar
- 5 x *Helleborus orientalis* subsp. *guttatus*
- 50–100 x *Galanthus nivalis*

Planting and aftercare

Work in plenty of well-rotted manure, garden compost, or leafmold to improve clay soil or make sandy or free-draining ground more moisture-retentive. Plant the border in fall or in mild spells during winter and early spring. Pot-grown snowdrops, or those lifted and replanted in clumps just after flowering, often establish better than dry bulbs planted in early fall. Mulch with chipped bark or cocoa shells to retain moisture and suppress weeds. Remove old leaves from the hellebores when the flowers start to open so that they don't mar the display. Also snip off dead or damaged leaves from the maidenhair fern when the new fronds unfurl.



Arum italicum subsp. *italicum* 'Marmoratum' ❄❄❄ ◑ ☀



Helleborus orientalis subsp. *guttatus* ❄❄❄ ◑ ☀



Galanthus nivalis ❄❄❄ ◊ ◑ ☀



Helleborus x *hybridus* cultivar ❄❄❄ ◑ ☀



Adiantum venustum ❄❄❄ ◑ ☀



Sparkling summer bed

This silver and pink color scheme is perfect for a sunny hot spot. Dotted through the planting, metallic-leaved astelia, commonly called silver spear, adds a distinctly Mediterranean feel. The compact form of the evergreen *Artemisia schmidtiana* appears like a shimmering river running through the border, with blue-leaved fescues on one side and pink-flowered thrift or sea pink on the other. The thrift (*Armeria*) blooms from late spring into early summer from wiry green tussocks. At the rear, the cut-leaved artemisia adds height and texture.

Border basics

Size 6 x 5 ft (1.8 x 1.5 m)
Suits Drought-tolerant grasses, alpines, and perennials
Soil Sharply drained
Site Hot, sunny, and sheltered

Shopping list

- 3 x *Astelia chathamica*
- 3 x *Artemisia ludoviciana* 'Valerie Finnis'
- 7 x *Artemisia schmidtiana* 'Nana'
- 7 x *Festuca glauca* 'Blauglut'
- 9 x *Armeria maritima* 'Splendens'

Planting and aftercare

Prepare heavier ground by digging in plenty of grit to improve drainage. This layout is best planted in late spring when the weather has become warmer and drier. Plants like the slightly tender astelia will have a chance to establish before winter and the grasses and silvery artemisias should be in active growth. To maintain the display, cut back dead heads on the thrift and, at the end of the season, the dead stems of the broad-leaved artemisia. Cover the astelia with floating row cover if a cold snap is forecast, and mulch with bark to protect the roots. In spring, tidy up the grasses by combing the dead leaves out of the tussocks with your fingers. Lightly trim the evergreen artemisia with shears.



Astelia chathamica
❄❄ 💧 ☼



Artemisia ludoviciana 'Valerie Finnis'
❄❄❄ 💧 ☼



Artemisia schmidtiana 'Nana'
❄❄❄ 💧 ☼



Festuca glauca 'Blauglut'
❄❄❄ 💧 ☼



Armeria maritima 'Splendens'
❄❄❄ 💧 ☼



Elegant fall border

This sparkling arrangement starts blooming in midsummer. First in flower is the pearly everlasting (*Anaphalis*) with clusters of papery ball-shaped heads, which remain attractive for many weeks, over gray-green felted leaves. Mingled in, the vibrant aster 'Veilchenkönigin' is a Michaelmas daisy with compact growth and good disease resistance. At the back, Russian sage (*Perovskia*) makes a delicate but long-lasting foil (try globe thistle, *Echinops*, as an alternative) and clumps of stipa add structure and movement.



Border basics

Size 6 x 4 ft (1.8 x 1.4 m)
Suits Late summer- and fall-flowering perennials and grasses
Soil Well-drained, neutral to alkaline
Site Open, full sun

Shopping list

- 3 x *Stipa calamagrostis*
- 5 x *Aster amellus* 'Veilchenkönigin' syn. Violet Queen
- 5 x *Perovskia atriplicifolia* 'Blue Spire' or 5 x *Echinops ritro*
- 7 x *Anaphalis triplinervis*

Planting and aftercare

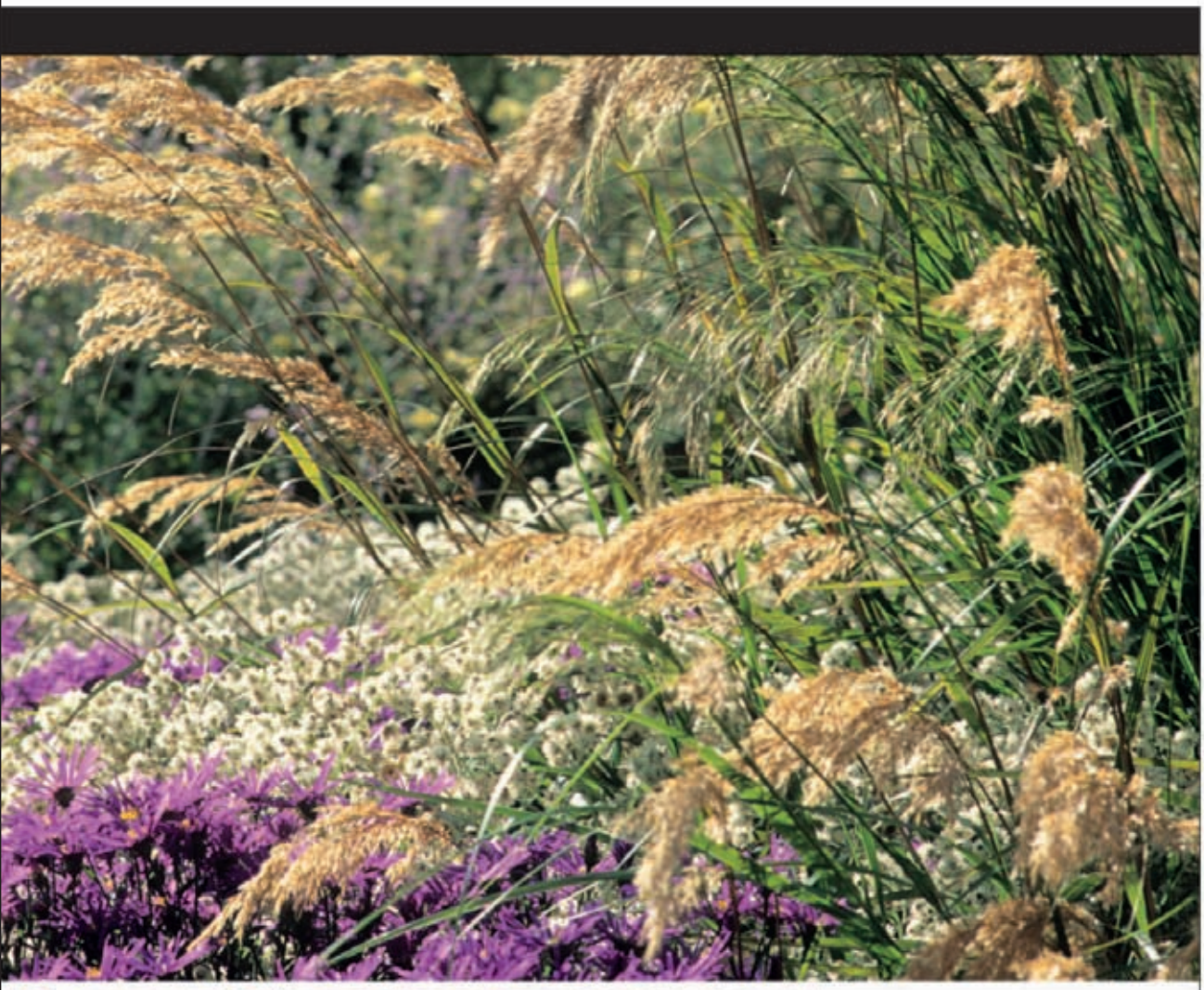
The plants in this plan enjoy fertile, well-drained soil, so remedy any drainage problems before planting in spring, and dig in organic matter if the soil is poor and dry. After soaking the pots, lay the plants out in long overlapping drifts. This arrangement suits relatively narrow borders because it creates the illusion of depth. Intermingle the asters and pearly everlasting where the two drifts meet to give a more naturalistic feel. Mulch to retain moisture, keep down weeds, and help plants establish through the summer months. In midwinter, cut down old flower stems of foreground plantings if they look untidy, but delay cutting back the grass and Russian sage until spring.



Stipa calamagrostis
❄❄❄ 💧 ☼



Aster amellus 'Veilchenkönigin'
❄❄❄ 💧 ☼





Perovskia atriplicifolia 'Blue Spire'



Anaphalis triplinervis

Alternative plant idea



Echinops ritro

Winter color

The flame-colored willow (*Salix*) sets this sunny border alight. It thrives in heavy soil, including waterlogged clay. Hard pruning in spring helps control its vigor, but in a small garden, consider using the dogwood *Cornus sanguinea* 'Midwinter Fire' instead. The ghostly white-stemmed rubus has dainty divided leaves in summer—a subtle contrast with the diaphanous stipa. In heavier soil, consider replacing this grass with the coppery pheasant's tail (*Anemanthele lessoniana*). In winter, the tawny red sedum flowers dry out, forming stiff, long-lasting maroon heads.

Border basics

Size 6 x 6 ft (1.8 x 1.8 m)
Suits Deciduous shrubs, grasses, and late-flowering perennials
Soil Fertile, well-drained, not too dry
Site Full sun

Shopping list

- 1 x *Salix alba* var. *vitellina* 'Britzensis'
- 1 x *Rubus thibetanus*
- 7 x *Sedum* 'Herbstfreude'
- 9–11 x *Stipa tenuissima*

Planting and aftercare

For best results, plant in spring to allow plants to establish before putting on a show through the winter. Cut the white-stemmed rubus and willow back hard the following spring to encourage plenty of new stems, which color up better than the old. Also cut back the grass foliage as you see new growth appearing, and clear away old sedum stems. Every three years, lift and split the sedum clumps in spring to keep them strong and stop them from collapsing during late summer. Apply a granular, slow-release fertilizer annually in spring and/or well-rotted manure at pruning time. Consider adding tall *Verbena bonariensis* for extra color in the "quiet" summer phase of this display.



Salix alba var. *vitellina* 'Britzensis'



Rubus thibetanus



Sedum 'Herbstfreude'



Stipa tenuissima



Cool foliage collection

In spring, the lungwort (*Pulmonaria*) puts on a display of white blooms, and the silver-spotted leaves that follow are just as attractive. The cream-variegated elder (*Sambucus*) brightens this shady spot, and clumps of dwarf boxwood (*Buxus*), along with the cherry-red stems of variegated dogwood (*Cornus*), maintain structure in winter. Tall flag iris makes a bold vertical statement and, though normally grown in water, its vigor is controlled in drier soil. Silver curry plants (*Helichrysum*) thrive in a patch of sunlight.

Border basics

Size 6 x 12 ft (1.8 x 4 m)

Suits Shade-tolerant shrubs and perennials grown for foliage contrast

Soil Fertile, moisture-retentive

Site Cool, lightly shaded

Shopping list

- 1 x *Cornus alba* 'Elegantissima'
- 1 x *Sambucus nigra* 'Marginata'
- 3 x *Helichrysum italicum*
- 3 x *Iris pseudacorus* var. *bastardii*
- 7 x *Pulmonaria saccharata* 'Sissinghurst White'
- 3 x *Buxus sempervirens* 'Suffruticosa'

Planting and aftercare

Most plants here would thrive in clay-rich soil. Improve dry soil by working in plenty of well-rotted manure. The curry plant requires sharply drained ground, so dig in plenty of grit before planting, or swap for pearly everlasting (*Anaphalis triplinervis*) as this tolerates clay and shade. Siberian iris (*Iris sibirica*) could also replace the flag iris. Mulch with bark after planting. Clip the boxwood to shape in early summer. In early spring, prune the elder back to a low framework and, once established, remove a third of the oldest stems of the dogwood. Prune the curry plant in spring to keep it bushy, and if mildew attacks the pulmonaria, cut back, fertilize, and water to aid regrowth.



Cornus alba 'Elegantissima'



Sambucus nigra 'Marginata'



Helichrysum italicum



Iris pseudacorus var. *bastardii*



Pulmonaria saccharata 'Sissinghurst White'



Buxus sempervirens 'Suffruticosa'



Architectural designs

All these plants have such a sculptural profile that the overall effect is very dramatic. The yellow-stemmed bamboo (*Phyllostachys*) makes an effective screen and, building a subtropical theme, two bold variegated yuccas dominate the foreground. Giant feather grass (*Stipa gigantea*) carries shimmering seedheads well into fall, its vertical form contrasting with the spreading tussocks of the New Zealand sedge (*Carex comans*). This bronze evergreen's color and form work beautifully with the broad, thick, textured foliage of the blue-leaved hosta and spiky black ophiopogon.

Border basics

Size 8 x 8 ft (2.5 x 2.5 m)
Suits Sculptural evergreens, bamboos, and grasslike plants
Soil Well-drained to moisture-retentive
Site Sunny

Shopping list

- 1 x *Stipa gigantea*
- 1 x *Phyllostachys aureosulcata* f. *aureocaulis*
- 2 x *Yucca filamentosa* 'Bright Edge'
- 3 x *Hosta sieboldiana* var. *elegans*
- 5 x *Ophiopogon planiscapus* 'Nigrescens'
- 3 x *Carex comans* bronze-leaved

Planting and aftercare

Prepare individual planting holes. The stipa, yucca, and ophiopogon thrive in sharply drained soil, so in heavier soil, work in plenty of grit. The sedges, hostas, and bamboo, meanwhile, enjoy moisture-retentive conditions. Improve dry, sandy ground by digging in well-rotted manure. Mulch with bark. The hosta has good slug resistance but watch for damage to new leaves. In spring, cut the sedge back hard, as the regrowth is more colorful, and trim back the old flower stems of the stipa. Cut a few older bamboo canes at the base to maintain an open habit.



Stipa gigantea



Phyllostachys aureosulcata f. *aureocaulis*



Yucca filamentosa 'Bright Edge'



Hosta sieboldiana var. *elegans*



Ophiopogon planiscapus 'Nigrescens'



Carex comans bronze-leaved



Easy perennials

With the right plants, you can sit back and enjoy fabulous flowering displays all summer long for next to no effort. This recipe combines colorful blooms and handsome foliage set off against the dark backdrop of a yew hedge. Relatively new on the scene, the blue cranesbill 'Nimbus' blooms from late spring to midsummer and is furnished with intricately cut foliage. Pincushion-flowered knautia takes over from mid- to late summer accompanied by tall spikes of the ornamental sage 'Ostfriesland'. The silvery felted lamb's ears (*Stachys*) and hairlike stipa make a textural foil.

Border basics

Size 5 x 6 ft (1.5 x 1.8 m)
Suits Easy-care perennials and grasses
Soil Fertile, moist but well-drained
Site Sunny

Shopping list

- 3 x *Geranium* 'Nimbus'
- 5 x *Knautia macedonica*
- 5 x *Salvia nemorosa* 'Ostfriesland'
- 3 x *Stachys byzantina* 'Silver Carpet'
- 5 x *Stipa tenuissima*
- *Taxus baccata* (hedge)

Planting and aftercare

Cut the yew hedge toward the end of summer; leave a gap between the hedge and the border for access. Improve poor, dry soil with well-rotted manure, garden compost, or spent mushroom compost. This arrangement is best planted in spring or early fall. Mulch with bark to control weeds. The following spring, cut plants back to new growth arising from the base—none of them should require staking, but pushing a few twiggy sticks in around the cranesbill in spring will help stop plants from sprawling too far. Deadhead the knautia as often as you can to prolong flowering. Cutting back cranesbill foliage after flowering encourages compact, new leafy growth.



Geranium 'Nimbus'



Knautia macedonica



Salvia nemorosa 'Ostfriesland'



Stachys byzantina 'Silver Carpet'



Stipa tenuissima



Taxus baccata



Contemporary prairie

This example of new wave or prairie-style planting is stylish and easy to care for. The ornamental sage, yellow foxglove, and verbena attract bees and butterflies, and if you leave this "meadow" to die down naturally, it will provide a valuable habitat for beneficial insects, small mammals, and birds. Flowering begins with the foxglove (*Digitalis*) and the violet-purple sage ('Mainacht' or 'May Night') in early summer, and reaches a peak in midsummer when the verbena joins the display. Giant feather grass (*Stipa*) throws up tall wands of glistening seedheads which, along with the verbena, last well into fall. You could consider maiden grass (*Miscanthus sinensis* 'Gracillimus') as a tall, narrow-leaved alternative to the stipa.

Border basics

Size 8 x 8 ft (2.5 x 2.5 m)
Suits Grasses, natural-looking perennials
Soil Fertile, well-drained but not dry
Site Sunny, open

Shopping list

- 5 x *Stipa gigantea* or *Miscanthus sinensis* 'Gracillimus'
- 9 x *Verbena bonariensis*
- 7 x *Salvia* x *sylvestris* 'Mainacht'
- 7 x *Digitalis lutea*

Planting and aftercare

Plant in early fall or mid- to late spring, improving dry or poor soil by adding well-rotted manure or garden compost. Lay out the plants in large overlapping blocks or swaths and use the tall, "see-through" verbena at intervals between shorter plants to create a more dynamic and naturalistic arrangement. All of the plants can be left to die down naturally at the end of the season, as the old flower stems and seedheads remain attractive well into the winter. Trim back in spring but leave the evergreen grass tussocks.



Stipa gigantea



Verbena bonariensis



Salvia x *sylvestris* 'Mainacht'



Digitalis lutea

Alternative plant idea



Miscanthus sinensis 'Gracillimus'



Aromatic herb border

Many traditional herb-garden plants have potential for use in low-maintenance plans, as they are mostly evergreen and drought-resistant. Here, aromatic lavender and common thyme blend with a cream-flowered cotton lavender (*Santolina*) and giant, silver-leaved cardoon (*Cynara*). Wispy bronze sedges weave through the planting, linking the various elements. The resulting slate-mulched bed has a muted, contemporary feel and would work well in full sun, adjacent to an open expanse of paving or decking. Add cream *Crocus chrysanthus* at the front for spring color.



Border basics

Size 6 x 5 ft (1.8 x 1.5 m)
Suits Drought-tolerant herbs, perennials, and sedges
Soil Reasonably fertile, sharply drained
Site Sunny, sheltered from wind

Shopping list

- 3 x *Santolina pinnata* subsp. *neapolitana* 'Edward Bowles'
- 5 x *Thymus vulgaris*
- 1 x *Cynara cardunculus*
- 5 x *Lavandula* 'Fathead'
- 7 x *Carex flagellifera*

Planting and aftercare

Plant between spring and early summer, to give the herbs a chance to establish before winter. Improve the drainage of clay soils by digging in grit or gravel. Soak plants, remove pots, and set out to make a pleasing arrangement. For weed-free gardening, plant through membrane and mulch with slate chips or gravel. Clip over the lavender after flowering in late summer and, in fall, tidy up the faded leaves and woody flower stalk of the cardoon. The following spring, cut the cotton lavender back to a low framework, and lightly trim the thymes. Trimming the sedges close to the base in spring encourages colorful regrowth.



Santolina pinnata subsp. *neapolitana* 'Edward Bowles' ❄❄❄ 💧 ☼



Thymus vulgaris ❄❄❄ 💧 ☼





Cynara cardunculus
❄❄❄ 💧 ☼



Lavandula 'Fathead'
❄❄❄ 💧 ☼



Carex flagellifera
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Chic foliage collection

The key to creating a contemporary look is to limit your plan to a single subject or just a handful of texturally interesting plants. Here the pink-leaved phormium adds height and vibrancy, its straplike foliage contrasting strongly with the bold, rounded leaves of the *Bergenia*. Flowering in spring, *Bergenia* 'Red Beauty' gives early-season interest and is followed by the simple white blooms of the convolvulus. An evergreen with leaves like strips of metal, the elegant convolvulus mirrors the silver container and complements the other plants, especially the "black" ophiopogon.

Container basics

Size Galvanized metal container, approx. 16 in (40 cm) in diameter
Suits Architectural evergreen shrubs and perennials
Soil Loam-based, free-draining potting mix
Site Sunny, sheltered from hard frosts

Shopping list

- 1 x *Bergenia* 'Red Beauty'
- 1 x *Ophiopogon planiscapus* 'Nigrescens'
- 1 x *Convolvulus cneorum*
- 1 x *Phormium* 'Jester'

Planting and aftercare

Metal containers heat and cool rapidly, potentially damaging roots, so insulate with a layer of bubble wrap or use a plastic pot as a liner, filling the gap with floating row cover. Cover the drainage holes with crocks and pour in 2 in (5 cm) of gravel. Half-fill with a good quality soil-based potting mix, adding slow-release fertilizer at the recommended rate. Arrange the plants to find the best fit, then plunge each pot into a pail of water, drain, and plant. Fill any gaps with more soil and water thoroughly. Water regularly, remove faded bergenia flowers, and renew fertilizer granules annually.



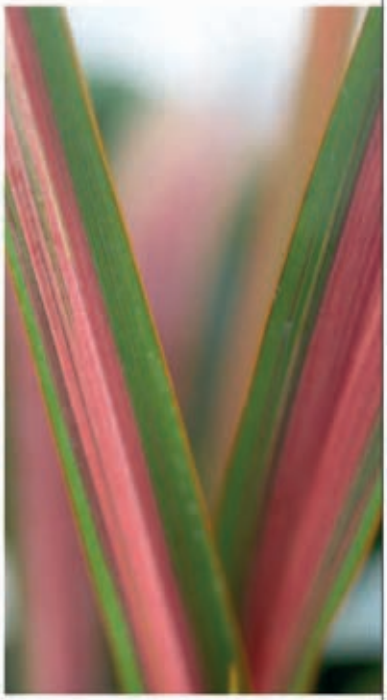
Bergenia 'Red Beauty'



Convolvulus cneorum



Ophiopogon planiscapus 'Nigrescens'



Phormium 'Jester'



Cottage garden in a container

Plain or decorated, terra-cotta tends to fit in well with older historic properties and traditional types of gardens, such as formal or cottage style. When buying, check that the pots are guaranteed frostproof and have no visible cracks or chips; a bell-like ring when struck indicates that the pot is sound. Being porous, clay is ideal for herbs, alpines, succulents, and drought-tolerant plants; if you want to use other plants, and still cut down on watering, it is best to line the pots with plastic.

Container basics

Size Terra-cotta pot, approx. 15 in (38 cm) in diameter
Suits Mediterranean-style perennials, herbs, and succulents
Soil Loam-based, free-draining potting mix
Site Sunny for most of the day

Shopping list

- 1 x *Lavandula angustifolia* 'Hidcote'
- 2 x *Scabiosa* 'Pink Mist' or *Osteospermum* 'White Pim'
- 1 x *Sedum* 'Ruby Glow'
- 2 x *Diascia* 'Sunchimes Lilac'

Planting and aftercare

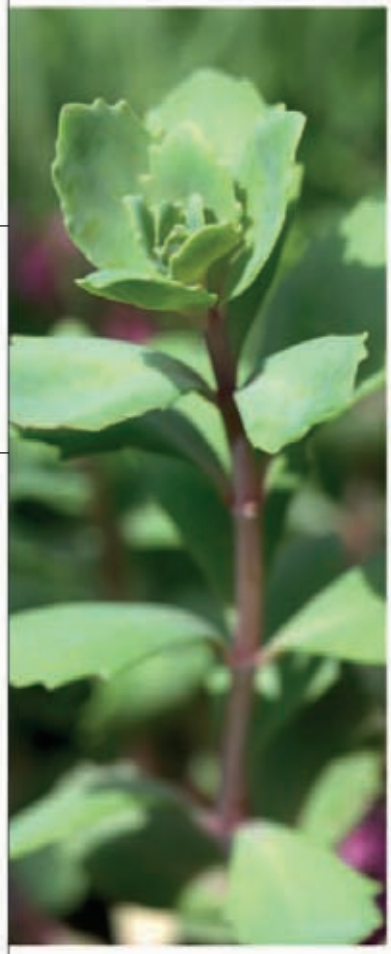
Soak the pot until the sides have turned a darker shade, indicating saturation, as this reduces the amount of moisture absorbed from the soil by the clay. Otherwise, line with black plastic, making sure that the drainage holes are uncovered. Protect the holes with fine mesh, flat stones or broken crocks, and add a layer of gravel for drainage. Half fill with loam-based mix combined with a slow-release fertilizer. After soaking the plants, arrange them to create a pleasing display. Carefully fill around the root balls, and finish at a final soil level 2 in (5 cm) below the rim to allow for watering. Regularly deadhead the scabious and diascia, and shear the lavender after flowering.



Diascia 'Sunchimes Lilac'



Lavandula angustifolia 'Hidcote'



Sedum 'Ruby Glow'



Scabiosa 'Pink Mist'

Alternative plant idea



Osteospermum 'White Pim'



Tidying up your garden

A well-planned, easy-care garden can be spruced up in no time, especially if lawns have been replaced by low-maintenance surfaces, and borders contain plenty of evergreens and nonflowering plants that don't need deadheading.

Garden facelift

During the growing season, weekly jobs, like mowing, deadheading, and sweeping, make a big difference to the look of the garden. Other tasks, such as hedge trimming and patio cleaning, as well as painting or refinishing various surfaces, may only be necessary once or twice a year. This "spring cleaning," however, is vital in easy-care gardens, where much more emphasis is placed on hard landscaping features. Shabby, mismatched fencing panels, peeling wall paint, faded decking, and paving slabs covered with algae catch the eye and mar your overall enjoyment. But if you have appropriate tools (some can be rented), you should be able to take care of such problem areas with ease.



Vacuum outside These handy but noisy tools allow debris, litter, and fallen leaves to be collected from paving and lawns, as well as from gravel and pebble surfaces, where it is difficult to use a brush.



Better mowing Maintain your own machine, or have it serviced regularly, to achieve the most efficient performance. Consider investing in a larger, more powerful mower if yours is too small for tackling the size of your lawn.



Keeping hedges trim Electric or gas-powered hedge trimmers are so much faster and less tiring to use than hand shears. To avoid raking up the debris, lay a tarp down to catch the trimmings.



Lift off dirt The strong jet of water produced by a pressure washer will lift grime and algae from paving, leaving a finish that looks like new. Test on a hidden corner first to make sure the surface won't be damaged.



Instant makeover Rolls of bamboo, willow, and heather screening can be used to cover mismatched fencing panels or ugly chain link for an instant and economical facelift. Attach with wire or plastic ties, or a heavy-duty staple gun.



Easy cover-up Repainting a wall freshens it up nicely, and applying a new color can add a designer touch to a patio or courtyard. After rubbing down the surface thoroughly, apply a quality exterior paint with a roller for ease.



Protect your wood Decking, fencing, trellises, and other wooden structures benefit from an application of all-weather paints, stains, and preservatives. Many companies offer special tools for speedy and efficient application.

Informal pruning

Most gardeners love the appearance of a naturalistic, seemingly unpruned garden, brimming with flowers and foliage. Although the look can be achieved with the minimal amount of work, to create this informal style takes a little practice.









Picture clockwise from left

Wild and free The scene of roses growing in the garden of an old-fashioned country cottage typifies the naturalistic look but, despite appearances, regular pruning has achieved this effect. Long, leggy growths that spoil the shape of the rambler on the wall are cut back into the main body of the plant as soon as they are seen. In fall or early spring, the plant is given a gentle overall trim to keep its shape. A hard pruning is needed every three to five years.

Beautiful berries Firethorns (*Pyracantha*) make excellent informal, burglar-proof boundary hedges, their thorny stems keeping unwanted visitors at bay. These shrubs come into their own in fall when covered in berries, and are pruned lightly in spring. Take care not to cut back too much, or you risk losing the berries.

Natural border The success of this scheme is no accident; clever plant selection and a careful pruning regimen ensure its natural appeal. If left completely unpruned, one or two plants would become dominant and take over. The silver-leaved *Santolina* and golden sage are lightly trimmed annually, while the *Hypericum* 'Hidcote' is pruned every two or three years to maintain its shape. When in full bloom, the border looks like it has never been pruned.

Color and texture A good planting combination and the correct plant spacing ensures that this border of *Ceanothus* 'Puget Blue', Mexican orange blossom (*Choisya* 'Aztec Pearl'), and shrubby honeysuckle (*Lonicera nitida* 'Baggesen's Gold') needs only minimal pruning. If vigorous plants had been chosen or this selection had been placed too close together, the border would need much more work. The stems of the *Ceanothus* are shortened annually after flowering (*see p.335*) and the sideshoots of the *Choisya* and shrubby honeysuckle are removed every two or three years to keep them balanced.

Pruning for a formal look

Trees and shrubs can be pruned and trained into many different shapes, and used to great effect in formal designs. Use them as focal points, to create views or backdrops, and to introduce shape and structure into the garden.





Pictures clockwise from top left

Pleached effects Trees such as lindens (*Tilia*) or hornbeams (*Carpinus*) can be trained into a structure that resembles a formal hedge on top of a series of straight trunks. This is achieved by training the branches horizontally so that they touch those of the next tree, which is trained in a similar fashion. Each year, the shoots that grow from these branches are pruned back to the main branch, resulting in a hedge with a distinctive structure. Use pleached trees to create high hedged effects or as a screen for a formal garden.

Plant patterns A parterre is made from hedges laid out in formal patterns and flowerbeds. The hedges can be of different heights and widths, and the designs intricate or simple. Plants used for a parterre must have a dense growing habit and be tolerant of close clipping, such as boxwood (*Buxus*) or yew (*Taxus*).

Rose covering Roses have been pruned and trained to cover the wooden supports that frame the view of the formal garden beyond. Mass plantings of hybrid tea and floribunda roses also add to the formal design.

Elegant head This beautiful shrub, *Viburnum rhytidophyllum,* has been pruned to create a stunning focal point. The lowest side stems have been removed, and the top allowed to form a branched head, which appears to float on its elegant "legs." This style of pruning can be practiced on many different plants but works best with evergreen shrubs.

Leafy canopy To create this leafy roof structure, several *Sorbus aria* have been trained so that the upper branches arch over to meet in the middle. No branches must be allowed to grow from the trunks, as this would spoil the effect, and those used to form the roof are pruned annually so the structure doesn't lose its shape. This eye-catching canopy takes many years to create.



Pruning to create space

Plants are often pruned to keep them in check, but some delightful effects can be achieved with more imaginative techniques, like clearing lower stems of trees and shrubs to create elegant shapes and extra planting space beneath them.



Pictures from left to right

Training standard bays Lollipop shapes are very useful in a garden's design, as they create interest and structure. Plants that are pruned to create a bare trunk are called "standards." This technique is an excellent way of confining the size of large shrubs and creating space underneath for a bed of shade-loving plants.

Tiny treelike wisterias If left unpruned, wisterias are large climbers, but it is possible to restrain them with careful pruning. Fruit trees can be trained and pruned in a similar way to fit restricted spaces.

Long-legged birches The most beautiful feature of a silver birch (*Betula*) is its gleaming white stem. To show the trunks off to the best effect, remove the lower branches. This opens up planting spaces beneath, which are perfect for shade-lovers, such as these *Rodgersia*. This pruning technique can be used for any tree or shrub with attractive bark.





Pruning to encourage flowering

Pruning plants correctly can increase the number of flowering shoots produced by the plant, giving you more flowers.

Knowing when and where to prune can make the difference between a poor show and a mass of color and scent.









Pictures clockwise from left

Purple rain A curtain of scented flowers in late spring, *Wisteria sinensis* needs to be carefully trained and spur-pruned each year in late winter to encourage flower bud formation (*see pp.172–173*). *Wisteria* grows very vigorously, so in midsummer, shorten the current season's growth by at least half, which also helps encourage the formation of flower buds.

Snowy summer show During early summer, *Philadelphus* 'Belle Etoile' is covered with large white scented flowers on arching branches. *Philadelphus* produces flowers on stems that formed the previous summer, so after it has flowered, remove about one-third of the oldest flowering stems, pruning them almost to ground level. Do this annually to help contain the overall size and shape of the plant and encourage plenty of new growth, which will be the flowering stems of the future.

Rose heaven Training a climbing rose, such as this *Rosa* 'Climbing Mrs. Sam McGredy', over supports shows off the blooms to their best effect. In late winter or early spring, remove approximately one-third of the oldest stems close to ground level. On the remaining older stems, spur-prune all the sideshoots and last year's flowering stems back to two or three healthy buds (*see pp.172–173*) from the main stem. Flowering growths will be produced from these spurs in the summer. At the same time, tie in strong new growth formed the previous year, which will need this support when they produce flowers.

Less is more *Clematis montana* is a vigorous plant, often grown over buildings and large plant supports. No pruning is required, but it may need trimming after blooming to keep it in check. In fact, some clematis are better left unpruned to encourage maximum flower production. In this instance, pruning reduces the volume of flowers that appear in late spring.

Pruning for colorful stems and bark

Some trees and shrubs produce bold, colorful stems and bark, which can be enhanced by careful pruning to create dazzling effects, especially during the winter when the branches are bare.





Pictures clockwise from top left

Bright highlights Grown for its attractive white peeling bark, the birch *Betula utilis* var. *jacquemontii* is especially effective in the winter when silhouetted against an evergreen backdrop. When the tree is young, use pruners in early summer to remove the lowest small branches. Then, when the stem has reached the height at which you want the branches to form, allow them to grow but continue to remove the smallest side branches. This will give you a simple yet strong, distinctive branch shape, and a clean white trunk.

Snakeskin decoration Unusual white striations on the green bark of *Acer* 'White Tigress' give rise to the tree's common name—snakebark maple. To see these markings at their best, create a clear stem of between 4 and 6 ft (1.2–1.8 m) by removing the lowest branches with pruners annually, until you have the required length of stem.

Show-stopping stems The dogwood *Cornus stolonifera* 'Flaviramea' is grown for its outstanding winter stem interest, with different cultivars ranging from green to orange and dark red. This dogwood is most effective when grown in groups of two or three plants. To achieve the striking winter stem interest, prune the plants annually in early spring using pruners (*see pp.168–169*).

Burnished bark A member of the cherry family, *Prunus rufa* is grown for its ornamental mahogany-colored bark rather than its flowers, and is ideal for small gardens. The beautiful bark looks best when you can see through the branch structure. To achieve this, remove all the smaller and crossing branches from the main structure.

Beautiful brambles *Rubus cockburnianus* is an ornamental suckering bramble grown for its attractive winter stems, which are white and red in color. This plant is both a beauty and a beast—the stems are covered in thorns and make an almost impenetrable barrier, so you will need to wear gloves and eye protection when pruning. To attain the attractive winter stem color, cut the stems to the ground annually in early spring.



Pruning for fruit

Fruit brings welcome color into the yard as well as edible treats. Fruit bushes and trees require a lot of pruning, but the blossoms and then the colorful and delicious fruit make it all worthwhile.



Pictures clockwise from left

Colorful blueberries The bushes of this popular fruit are of great value: they flower in the spring, fruit in the summer, and then provide lovely foliage color in the fall. Blueberries fruit on branches produced the previous year. Prune the bushes during the winter, removing two or three of the oldest stems each year, as well as any weak, dead, or diseased growths. Also remove any of the lower branches that may lie on the ground when laden with fruit in the summer.

Decorative apples Apple trees are beautiful in blossom and when covered in fruits. When choosing an apple tree for your yard, bear in mind that different varieties grow at different rates, so look for one that suits the size of your yard and the space available. Prune apple trees in the winter to give an open, airy structure. Do not prune too hard as this stimulates vegetative growth at the expense of flower buds and fruit.

Productive pears Pear trees are suitable for small yards if trained in a pyramid shape. To keep a tree small, reduce the length of the main leader (the tallest stem at the top of the tree) in winter. Also remove any congested growths during the winter when you can clearly see the skeleton of the tree. Then, in late summer, reduce the side branches by pruning them back to one leaf bud from the main stem. Pear trees will fruit without any pruning, but they can become too large for a small yard.

Wall-trained espaliers One of the most beautiful and artistic ways to grow an apple tree is to train it as an espalier against a wall, where pairs of branches are trained horizontally from the central stem. Apple espaliers are suitable for small yards, but require great care and maintenance. During the late summer, prune all the sideshoots, taking each one back to the first noticeable leaf above the main horizontal branch. As the plant grows older, the branches that produce fruit will become crowded and will then require thinning in the winter.



Choosing pruning tools

Using the right tool for the right job is one of the most important factors when pruning. Choose your tools carefully and look for good-quality products that are safe to use and make sharp, clean cuts that won't damage your plants.





Pruners There are two types of pruners: anvil (*above*) and bypass (*right*). The cutting blade of anvil pruners presses down onto a metal block edge, while the bypass's cutting blade passes the bottom blade in a scissor action. Bypass pruners give a cleaner cut and are easier to use. Only use pruners for cutting stems less than ½ in (1.5 cm) in diameter.



Pruning saw An essential tool, this saw has either a folding or fixed blade that can be replaced when it is worn or damaged. Pruning saws are good for awkward situations.



Long-armed saw Use this saw for cutting small branches above head height. Always wear eye protection and a safety helmet, and save large branches for the professionals.



Bow saw Only use this tool for cutting branches that have already been pruned and removed. The shape makes it unsuitable for use in difficult and awkward situations.



Loppers Often used for pruning branches that are too thick for pruners—although a pruning saw is the ideal tool—or for reducing the length of branches and stems. When using loppers, don't employ excessive pressure, as you can easily twist and crush the pruned stem.



Long-armed loppers If you need to shorten stems, or remove dead or diseased material that is above head height, this is a useful tool. Never use long-armed loppers to cut stems more than 1 in (2.5 cm) in diameter as they can be quite difficult to control.



Electric hedge trimmer Useful for cutting most types of hedges. Always work from the bottom to the top, make sure the cord is behind you, use a GFI outlet, and never use in damp or wet conditions. Wear ear protection and read the instructions before use.



Gas hedge trimmer Usually much heavier than electric types, gas trimmers can be tiring to use for long periods. They will saw through most hedges, and are useful for cutting those with thick sideshoots. Always wear ear protection and read the instructions carefully.

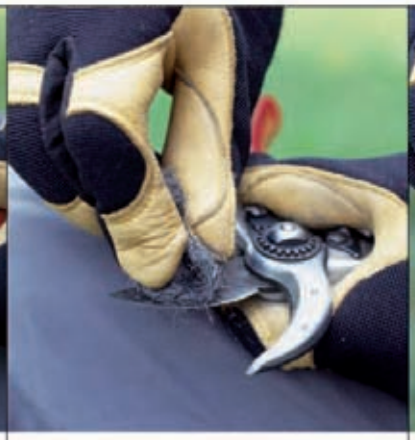
Tool care and safety tips

Using the right pruning tools and correct safety equipment helps to ensure that pruning is safe and enjoyable. You will also protect yourself against accidents if your equipment is well maintained, and extend the life of your tools.

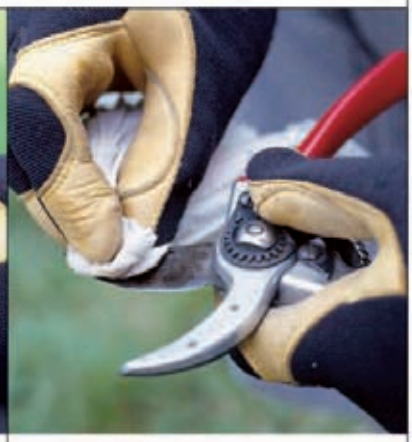
Cleaning pruners



1 When pruning, plant sap dries and sticks to the blades, making them stiff. Scrape off the sap using a piece of metal with a straight edge, such as a metal plant label or penknife.

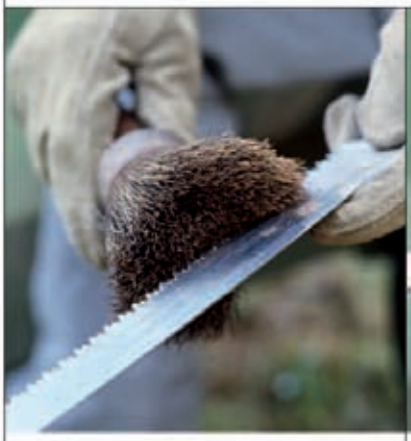


2 Then rub the blade with steel wool to remove any remaining dried sap and rust or other material. To prevent accidental cuts, wear gloves while cleaning your blades.



3 When the blade is clean, rub on some lubricating oil. This guards against rusting, and keeps the pruners sharp and clean while they are being stored.

Cleaning pruning saws



1 When you have finished pruning, use a coarse brush to remove any sawdust lodged in the saw's teeth. If this is left, it can harden and reduce the saw's cutting ability.



2 Next, use steel wool to rub both sides of the saw blade. This removes dried sap and dirt, which can also make the saw less efficient.



3 Before putting the saw away after cleaning, rub some lubricating oil onto it with a cloth to protect the blade from rusting.



Wear gloves Always wear sturdy gloves when pruning to protect your hands from sharp tools, and from cuts and scratches caused by thorny or sharp-edged plants.



Use protective goggles Protect eyes from dust, sawdust, and plant trimmings, especially when working above head height. Goggles also protect against thorns and shoots.



Keep electric wires behind you When using electric hedge trimmers, ensure that the cord is behind you so you cannot cut through it, and plug it into a GFI outlet.



Making ladders safe Use a tripod ladder, and ensure it is stable by fully extending the legs. Don't over-stretch or lean out to either side. If possible, ask someone to stand at the bottom.



Using platforms and ladders Before using this equipment, ensure that each set of legs is on level ground and adjust if not. Do not over-stretch or lean out too far on either side.

Pruning your neighbor's plants Before pruning plants that are overhanging your yard, speak to your neighbors. You are more likely to reach an agreement about how much to cut off if you maintain a good relationship. However, branches that overhang your yard may be classed by law as trespassing on your space, and you may have the right to cut them back to your boundary; check the laws in your state or province before you start. The branches that you have cut and any fruit that was on them should then be returned to your neighbor. You are not allowed to enter your neighbor's property, or to lean over it to prune your hedge, without seeking permission first.

The dangers of chain saws Always call in a trained arborist to cut down large branches that can be only safely removed with a chain saw. Do not attempt to use one yourself.

Essential pruning jobs

Most pruning tasks are performed annually, but those outlined here need immediate attention and are best tackled as soon as problems are seen.



Crossing and rubbing branches
Branches that have grown too close together and are rubbing against each other are a common problem. If you spot these, remove one of the branches, either the weakest one or the stem that has suffered the most damage. Branches that rub each other can create open wounds through which disease may enter the plant, causing serious problems.

Removing suckers

A sucker is a vigorous strong growth that emerges from a point low down on a plant, close to the root system. If left, it can choke the plant or reduce its vigor. Such shoots are normally found on plants that have been grafted, such as roses, and usually look quite different from the rest of the plant. If seen early, remove such a shoot by quickly tugging it away with a gloved hand, or if it has grown too large, remove the shoot using pruners.



A sucker growing from below the graft (knobby bulge) on a rose

Cutting out reverted leaves

Reversion is when the leaves of a variegated plant turn pure green. If left to grow, these green shoots, which have greater vigor, can take over and ruin the appearance of the plant. When you see any shoots that are showing signs of reversion, remove them completely using pruners, and make sure that you prune back to where the shoots are still all variegated. This can be done at any time of the year.



Remove green shoots from variegated plants like *Euonymus* cultivars

Dealing with twin leaders

Twin leaders occur at the top of a tree when two stems of similar vigor are growing close together. Remove the weaker stem using pruners. If left unpruned, the stems will try to grow away from each other, causing a weakness to develop. One stem may then break away from the tree, causing serious damage. Although this may not happen until the tree is much older, prompt action when the plant is young will prevent future problems.



Remove the weaker stem



A single leader has strength

Limiting frost damage

Buds and young shoots can be damaged when caught by spring frost. Prune plants back to healthy, unfrosted buds to prevent dieback or diseases from starting at the frosted points. Most plants will then produce new growths lower down the stems. However, on some plants, such as *Hydrangea macrophylla*, frost may damage all the new flower buds produced on the previous season's growth, and you will lose the coming year's blooms.



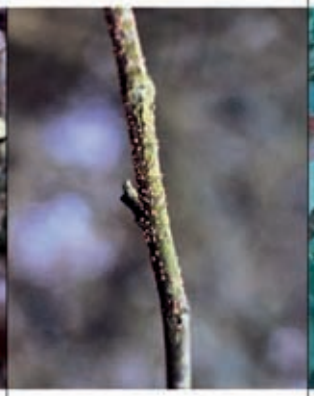
Hydrangea macrophylla 'Libelle' with frost damage

Cutting out dead and diseased wood

Whenever you see dead or diseased wood on any tree or shrub, remove it immediately. If dead wood is left on a plant, disease can enter more easily and it may move down the stems, attacking healthy growth. Dead wood also looks unsightly. When a tree or shrub has been damaged, its natural defenses will eventually form a barrier in the form of a slight swelling between the live and dead wood. In this instance, remove the dead wood above the barrier.



Dead wood on a hornbeam



Coral spot on a branch

Deadheading to promote flowering

The removal of dead flowerheads can encourage many repeat-flowering plants, like roses, to produce more blooms. These dead flowers can be snapped off with the fingers, or removed using pruners. On some shrubs, like rhododendrons, removing the dead flowers encourages the plant to produce more stems, rather than wasting its energy on making seeds. This enables the plant to produce more flowers the following spring.

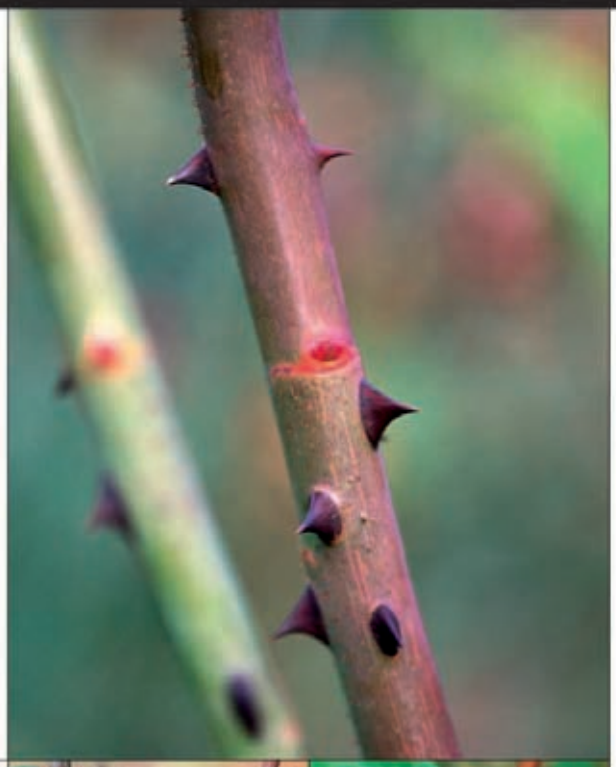


A dying rose bloom can be easily snapped off by hand

Making pruning cuts

Trees, shrubs, and climbers grow in many different ways, and their shoots, buds, and stems may look completely different too. To avoid confusion, before you start pruning, try to identify the position and type of buds and shoots on your plant, and then make your cuts.

Identifying a shoot bud Buds come in many different shapes, sizes, and colors. Some are slight swellings or raised bumps on the stems; others may be a different color from the rest of the stem, such as rose buds (*see right*). Buds are always produced at the point where leaves are growing, or have previously been attached to the stem. When pruning, you always cut immediately above a bud, which stimulates hormones in the plant to make the bud develop into a new stem.





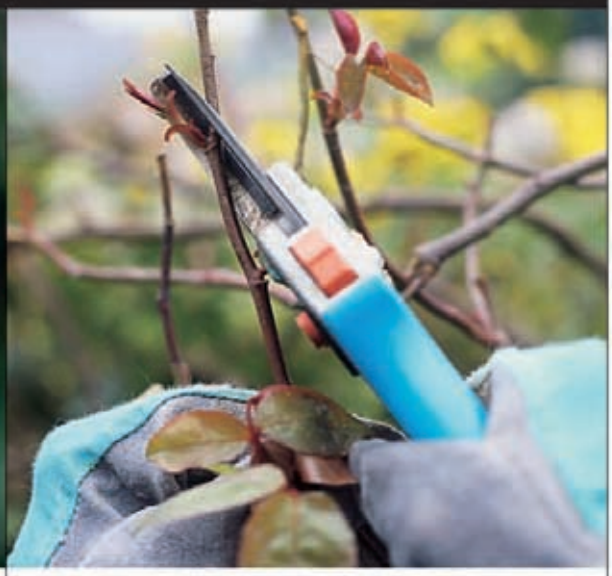
Pruning to a new shoot A new shoot is normally light green in color and looks quite obvious, as on the clematis shown here. New shoots can be quite soft and delicate, and you have to be careful not to damage or break them when pruning back to the new growth.



Pruning to new growth You can recognize the new growth on a plant because it looks much fresher than old wood. When pruning, cut off the old wood just above a new stem, using a sloping cut so that excess moisture runs away from the young growth.



Cutting opposite buds The buds of some plants, such as dogwoods (*Cornus*) and hydrangeas, are opposite each other. Prune immediately above a pair of buds with a flat, straight cut. When the buds grow, they will produce two shoots growing in opposite directions from one another.



Cutting alternate buds The buds of plants such as roses and wisteria grow alternately along the stems. Try to prune to a bud that is facing outward, away from the center of the plant. Make a sloping cut immediately above the bud, so that excess moisture runs away from the bud.



Using a pruning saw If the stem you intend to prune is thicker than a finger, use a pruning saw to make the cut. Many stems are spoiled by attempting to cut them with incorrect tools. Pruning saws make a much cleaner cut than loppers. Always wear protective gloves.



Shearing When cutting shrubs or hedges with a dense habit, such as yew (*Taxus*) or boxwood (*Buxus*), hand shears are the best tool for the job. Shears are also very useful for trimming lavenders and heathers. Make sure the shears are sharp and clean so you get a good clean cut.

Removing branches

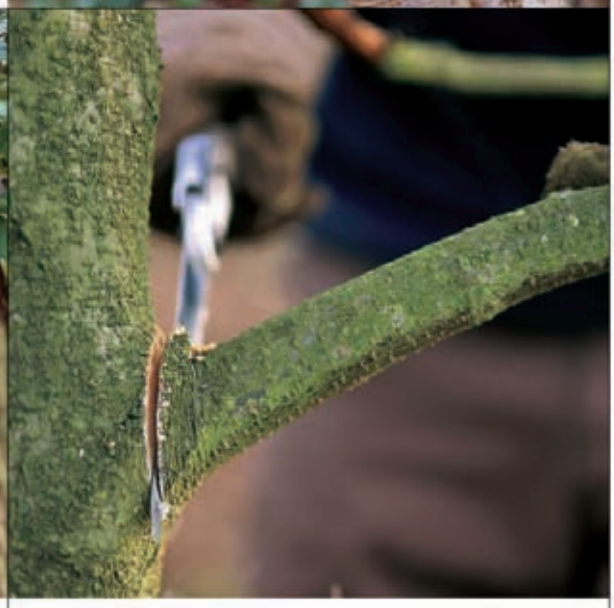
It is very important to remove a branch correctly. Bad or rough cuts can reduce a plant's ability to heal itself, which may then allow disease to enter the wound. Eventually this can cause rotting, reducing the plant's life span.

Hard to reach branches Branches that are difficult to reach can lead the person who is pruning to take shortcuts. Mistakes are more often made when one is attempting to prune from a distance. If the branch that needs to be pruned cannot be reached safely by a ladder, seek the help of a trained and experienced arborist. If a small branch is not too high, it may be possible to prune it with a long-armed lopper or pruning saw, following the same procedure shown opposite.





Torn branches A heavy branch is likely to tear when being pruned, as its weight will pull down the stem and rip it before you can complete your cut. If you don't have someone to hold the branch while you prune it, shorten it in stages before attempting the final cut. Also make an undercut first (*see Step 1, facing page*), which helps to prevent tearing when you cut through it from above.



Bad cuts Never cut flush to the trunk of the tree, as this removes the tree's own healing system. It can look tidy to begin with, but the stem will not heal properly, and the open wound may then allow disease to enter the tree. Cutting branches flush with the trunk is one of the major causes of decay and ultimately death in trees.

How to remove a branch



1 Reduce the weight of a heavy branch by cutting it back to leave a 6-in (15-cm) stump. Then make the final cut. To prevent tearing, first make an undercut where the branch starts to swell or 1¼ in (3 cm) from the trunk.



2 Stop cutting when you are about halfway through the branch. Then make another slightly angled cut from the top, just behind the crease in the bark where the branch meets the trunk. Be sure the upper cut meets the undercut.



3 This pruning method results in a clean cut, and preserves the "collar," part of the plant's healing system. The cut surface will begin to shrink as the tree produces protective bark, which will eventually cover the exposed area.

Tip for success



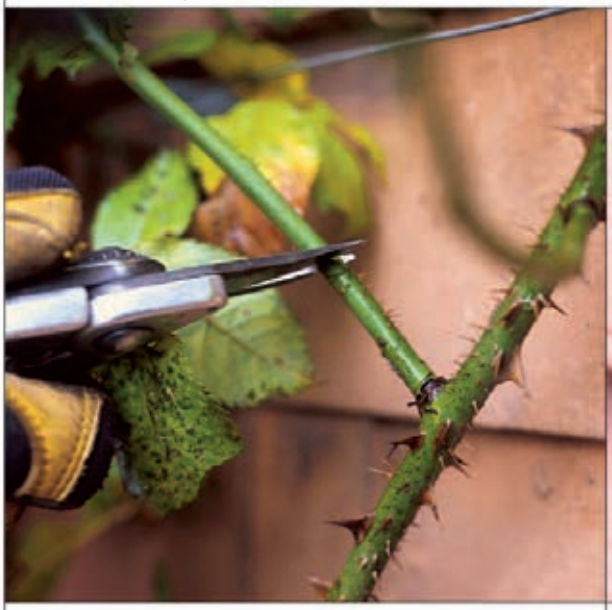
When cutting a heavy branch, ask someone to help support the weight when you saw. This helps to prevent tearing. It can also stop the branch from swinging or falling, and damaging the plant being pruned or injuring the person who is pruning.

Spur pruning

Spur pruning encourages bud formation on trees, shrubs, and climbers. Where this rose has been spur-pruned, it has produced three new stems, each of which will flower.



Spur-pruning a rose



To spur-prune a climbing rose, find a healthy sideshoot growing from one of the main stems. Count two or three buds from the stem along the shoot. Make an angled cut immediately above this second or third bud, sloping away from it. Repeat farther up the main stem.



After pruning, you will be left with short growths, which are described as "spurs." From the buds on these spurs, two or three flowering stems will emerge, depending on how many buds were left on the spur.

Spur-pruning wisteria



Spur-prune wisterias in late winter. Using pruners, shorten each new shoot that has grown the previous season, so that two or three healthy buds remain. Always make the cut immediately above the outermost bud and sloping away from it.



This picture shows the stems once they have been shortened to two or three buds. The buds on the short spurs will swell to produce flowers or flowering stems in late spring and early summer, producing cascades of sweetly scented purple or white blooms.

Pruning hydrangeas

Hydrangea paniculata flowers in late summer on stems it has made that same year. To keep the plants compact, prune in early spring to promote new flowering wood. This also encourages larger flower panicles in the summer.



Hydrangea paniculata is an elegant plant with wonderful large conelike flowerheads. Most have white flowers, but there are also cultivars that are tinged with pink. They make excellent shrubs for the late summer garden.



1 In late winter or early spring, prune last season's stems to one or two buds from their base. Also take out any dead, diseased, crossing, or weak branches.



2 Any large, unhealthy branches should be cut back to healthy wood or to the base using a pruning saw. This prevents disease from spreading to the rest of the plant and promotes the growth of new, vigorous stems.



3 After pruning, you will be left with an open framework of branches. These will produce a mass of growth during the summer and an abundance of beautiful white flowers.

Hydrangea macrophylla, or florist's hydrangea, flowers in summer from buds that have already been set the previous summer. These buds are prone to frost damage in the spring months, and plants need careful pruning.



Hydrangea macrophylla produces sumptuous large flowerheads in blue, pink or white during the summer months, before *H. paniculata*. To ensure a good display, the developing flower buds need some frost protection throughout winter.



1 The hydrangea's old flowerheads help to protect the delicate new flower buds from frost, so leave them on the plant during the winter months. The dried flowers also add structure and interest to the winter garden.



2 When the danger of hard frost has passed in late spring, remove the flowerheads by pruning the stems back to a pair of healthy buds, as shown.



3 Do not be tempted to prune too hard, as this will remove many of the flower buds, which will have already formed on the stems that grew the previous year. New stems that grow in the coming year will bloom the following summer.

How to prune a smoke bush

Grown for their outstanding summer and fall foliage, and tiny, cloudlike flowers, smoke bushes (*Cotinus*) are best pruned annually in the spring.

Other plants to prune this way

- *Catalpa bignonioides*
- *Cotinus coggygria*
- *Rhus chinensis*
- *Rhus typhina*
- *Sambucus nigra*
- *Weigela* 'Praecox Variegata'
- *Weigela* Wine and Roses



Foliage effects

Pruning hard encourages the plant to produce larger, more decorative leaves, although you may lose the smokelike blooms.



1 Mature smoke bushes can outgrow their allotted location and suffer from dieback. Both problems are easily remedied by cutting plants back hard in the spring before the leaves appear.



2 First, remove any dead growth using a pruning saw. Also cut out diseased stems, taking them back to healthy growth. When removing large branches, cut them back in stages to ensure that they do not tear.



3 To keep a cotinus small and compact, cut back all of the taller branches to about 2 ft (60 cm). Prune to healthy wood, which you can identify by checking that it is green in color beneath the bark, and make sloping cuts.



4 Continue around the plant until you are left with a core structure of stems, each no higher than 2 ft (60 cm). New growth will soon start to sprout, resulting in plenty of fresh foliage that will provide exciting fall color.

Pruning witch hazel

With their fragrant, spidery flowers, witch hazels (*Hamamelis*) are wonderful shrubs in winter, but if left unpruned, they can become too large for a small garden.

Tip for success



Prune witch hazels just as the flowers are fading but before the leaves unfurl. Cut just above a healthy young sideshoot.



1 To reduce the size of this plant, in early spring prune back the taller branches by 12–20 in (30–50 cm). Try to keep in mind the overall shape you are aiming to achieve.



2 While pruning, step back occasionally to look at what you have cut out, and what still needs to be done. Always prune out old stems, leaving healthy young growth.



3 Occasionally you may find some crossing branches in the center of the bush that are difficult to reach. If a branch is awkwardly positioned, it may be easier to cut upward from below the branch.

Tip for success



If you are not sure how much to remove, reduce the length of the stems a little at a time. Stand back, and then prune more if needed, until you have created an attractive overall shape.

How to prune shrubby honeysuckle

Prune winter-flowering shrubs, such as *Lonicera x purpusii* 'Winter Beauty', in early summer. Remove the oldest flowering stems to encourage new, strong shoots to grow from the base.



Tip for success

It is much easier to use a pruning saw to cut through branches that are too thick for either loppers or pruners.



1 First, reduce one-third of the oldest stems on the plant. Use loppers to cut back their length by about half, thereby decreasing the weight of the stem and preventing tearing, before you make the final cut closer to the ground.



2 With the loppers or a pruning saw, cut back to 12 in (30 cm) above the ground the stems that you have already pruned by half. Make a sloping cut immediately above a sideshoot to allow rain to run off the cut surface.



3 Using pruners, shorten the tallest of the new stems, which may be over 6 ft (1.8 m) high, by several inches (centimeters). This encourages buds farther down the plant to shoot, creating a bushier plant with more flowers.



4 When you have finished pruning, you should still have some older stems that will produce flower buds the following winter. The strong young growths coming from the base will now have more room to develop.

Hard-pruning a camellia

Evergreen shrubs, such as camellias, that have outgrown their position can be hard-pruned in late spring or summer, just after they have finished flowering.

Other plants to prune this way

- *Aucuba japonica*
- *Elaeagnus pungens*
- *Erica arborea*
- *Escallonia*
- *Fatsia japonica*
- *Prunus laurocerasus*
- *Prunus lusitanica*
- *Viburnum tinus*



New growth

A year after pruning, the plant will have produced a mass of young stems but may not flower for a further two or three years.



1 This plant has outgrown its location and now needs to be cut back hard. Camellias respond very well to severe pruning, a task best performed immediately after they have finished flowering in late spring or early summer.



2 Use a pruning saw to reduce the height of the plant. To prevent tearing, cut back large, heavy branches in stages, rather than cutting off long sections.



3 Loppers are ideal tools for pruning back awkwardly placed side stems, allowing you to reach them more easily. But the final cut close to the main branch must be made using a pruning saw, as it gives a cleaner cut.



4 Aim to reduce the plant's height to about 24 in (60 cm). By the time you are finished, the camellia will resemble a small wooden stump, but it will not take long for new shoots to start growing (*see opposite page*).

Cutting back California lilacs and philadelphus

Most California lilacs (*Ceanothus*) have vivid blue flowers in early summer. If left unpruned, they can become large and untidy, but if cut back too severely, the plant will not regenerate. Prune immediately after flowering is finished.



1 Here you can see an evergreen *Ceanothus* in full bloom in early summer. To maintain its compact shape, it will need to be lightly pruned later in the summer, after it is finished flowering.



2 After flowering, you can more clearly see the branch structure of the plant. To keep it in good shape, cut back long, untidy branches by 9–12 in (22–30 cm), but leave some of the shorter stems unpruned.



3 Use pruners to prune the branches, and make each cut immediately above a leaf bud. This will encourage the plant to produce growths from below the cut, resulting in a compact branching structure.



4 After pruning, the overall size of the plant is reduced, but it has not been cut back too severely, which would weaken it. If pruned like this annually, the *Ceanothus* will remain neat and bushy, suitable for a small garden.

Philadelphus has white, scented flowers in early summer. Prune the plant after flowering to encourage the formation of new growths, which will bear flowers in the future. An annual pruning also helps to contain the size of the plant.



1 In early summer, mock orange (*Philadelphus*) is a mass of white scented flowers. As soon as flowering is finished, cut back about a quarter of the oldest flowering stems to 6 in (15 cm) above the ground.



2 Cutting back hard some of the oldest stems promotes the formation of new shoots below the pruning cut, but do not be tempted to remove all the old stems, as this will reduce the volume of flowers the following summer.



3 Check the remaining old stems for young growths. These are best shortened rather than being hard-pruned. Take off the top third of these young stems, and prune them back to new wood.



4 Finally, trim the tips of any strong young stems that are already present in the plant—some may be as tall as 8 ft (2.5 m). This encourages them to branch lower down, which results in more flowers.

How to prune a patio rose

Patio roses are small, repeat-flowering plants that can be grown in borders or containers. Prune them in early spring to encourage a mass of new shoots that will flower in the summer.



Tip for success

As well as pruning your rose every year, encourage it to keep flowering for longer by removing the blooms as they fade.



1 The aim of pruning is to reduce the plant's height by one-quarter to a half and to create an open shape. Cut back the outer stems, and then remove dead, diseased, and damaged growths, plus any weak or crossing stems.



2 Always prune above a strong outward-facing bud if possible. Ensure that the cuts are sloping so that rainfall runs away from the bud, reducing the chance of its rotting.



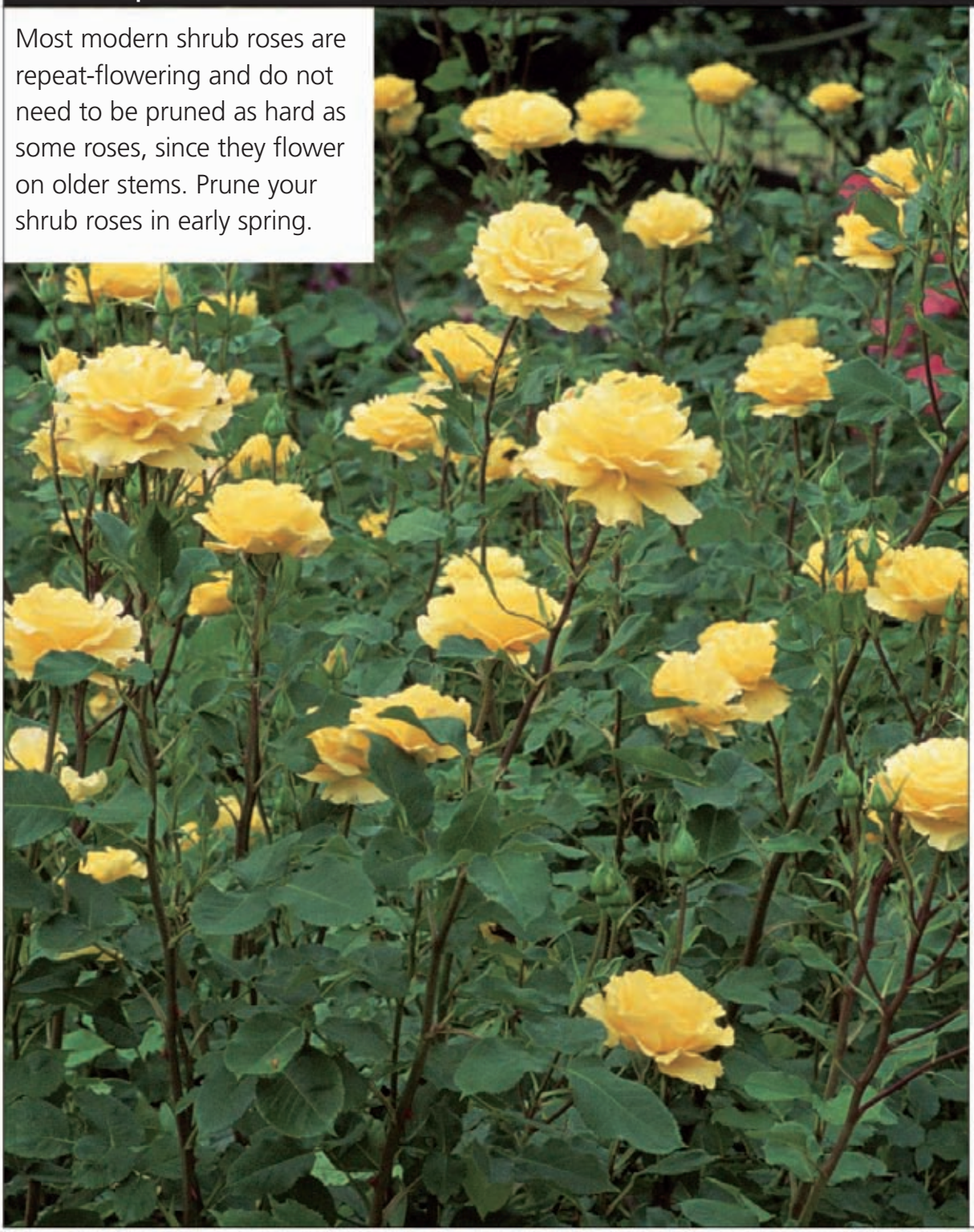
3 This strong stem is being cut back by one-half, which will encourage many strong flowering shoots to grow from it in the forthcoming summer.



4 As well as producing more flowering stems, the resulting simple framework allows air movement, which reduces the incidence of fungal diseases. Fertilize and mulch roses after pruning to further encourage healthy growth.

How to prune a shrub rose

Most modern shrub roses are repeat-flowering and do not need to be pruned as hard as some roses, since they flower on older stems. Prune your shrub roses in early spring.





1 The aim of pruning a shrub rose is to create a strong structure and to remove congested stems that were produced the previous year. This improves air flow through the plant, which helps prevent fungal diseases.



2 Cut off any dead, damaged, or diseased branches. Then remove any weak shoots not strong enough to support new flower growths. Also prune a few of the oldest stems down to the ground.



3 Reduce healthy main stems by a quarter, and prune some of the sideshoots by just a few inches (centimeters). Always cut above a healthy bud that faces outward, away from the center of the plant, if possible.



4 The pruned plant should be reduced in height by about a quarter, and have a strong, open structure that appears uncluttered in the center. By midsummer the plant should be covered in beautiful blooms.

Pruning other types of roses

Different types of roses have different pruning needs. Identify your roses and then follow these guidelines to ensure that yours produce their best show.



Old garden roses

These roses normally have one flush of flowers each year. Prune in early spring, first removing any dead, damaged, diseased, weak, or crossing branches. They do not need severe pruning: aim to reduce the size of the plant by one-third. Always make a sloping cut above an outward-facing bud. In the fall, cut back the stems by one-third to reduce the risk that wind will rock the plant and damage the roots.

Examples of old garden roses

- *Rosa* 'Blanche Double de Coubert'
- *Rosa* 'Boule de Neige'
- *Rosa* 'Charles de Mills'
- *Rosa* 'De Rescht'
- *Rosa* 'Fantin-Latour'
- *Rosa* 'Frau Dagmar Hartopp'
- *Rosa* 'Louise Odier'
- *Rosa* 'Madame Isaac Pereire'
- *Rosa* 'Madame Pierre Oger'
- *Rosa* 'Maiden's Blush'
- *Rosa mundi*
- *Rosa rugosa*
- *Rosa rugosa* 'Alba'
- *Rosa* 'Souvenir de la Malmasion'
- *Rosa* 'William Lobb'



Hybrid tea roses

This group of roses normally flowers more than once during the summer months. They respond well to hard pruning in early spring. First remove all dead, damaged, diseased, weak, or crossing stems, and then prune out the oldest stems, taking them back to the ground. Leave between three and five young, strong stems, which should be pruned to a height of 6 in (15 cm) above the ground. As a guide, stand your pruners on the ground, and as these are normally about 6 in (15 cm) long, they will show you how far to prune back the stems. Always make a sloping cut above an outward-facing bud, if possible. In late fall or early winter, reduce the height of the stems by one-third to reduce the risk that wind will rock the plant and damage the roots.

Examples of hybrid tea roses

- *Rosa* Alexander
- *Rosa* 'Blessings'
- *Rosa* Dawn Chorus
- *Rosa* 'Deep Secret'
- *Rosa* Elina
- *Rosa* Freedom
- *Rosa* Ingrid Bergman
- *Rosa* 'Just Joey'
- *Rosa* Lovely Lady
- *Rosa* Paul Shirville
- *Rosa* Peace
- *Rosa* Remember Me
- *Rosa* Savoy Hotel
- *Rosa* 'Silver Jubilee'
- *Rosa* Tequila Sunrise
- *Rosa* Troika
- *Rosa* Warm Wishes







Floribunda roses

Floribundas are repeat-flowering roses that produce clusters of blooms during the summer months. Pruning is very similar to hybrid tea roses, but not quite as hard. First, remove all dead, damaged, diseased, weak, or crossing stems. Your aim is to leave a framework of between six and eight of the strongest, youngest stems. Prune them to a height of between 8 and 12 in (20–30 cm), always make a sloping cut just above an outward-facing bud, if possible. In the fall or early winter, reduce the height of the stems by one-third to reduce the risk of damage if wind rocks the plant and disturbs its root system.

Examples of floribunda roses

- *Rosa* 'Arthur Bell'
- *Rosa* 'English Miss'
- *Rosa* Fascination
- *Rosa* Fellowship
- *Rosa* 'Fragrant Delight'
- *Rosa* Iceberg
- *Rosa* Memento
- *Rosa* Pretty Lady
- *Rosa* 'Princess of Wales'
- *Rosa* Queen Elizabeth
- *Rosa* Remembrance
- *Rosa* Sexy Rexy
- *Rosa* Sunset Boulevard
- *Rosa* Tall Story
- *Rosa* The Times Rose
- *Rosa* Trumpeter

Extending flowering

Deadhead repeat-flowering roses throughout the summer to encourage them to bloom for a longer period. By removing the flowers, you prevent the plant from using its energy to form seed and stimulate it to produce more flowers instead. The easiest way to do this, and the way now practiced in many large gardens, is to bend the stem just below the old flower, as shown, until it snaps off. The plant will soon start forming new flower buds. Alternatively, use pruners to remove the flower and about 6 in (15 cm) of growth. The plant will then form more flower buds, but it normally takes longer than the "snapping off" method.

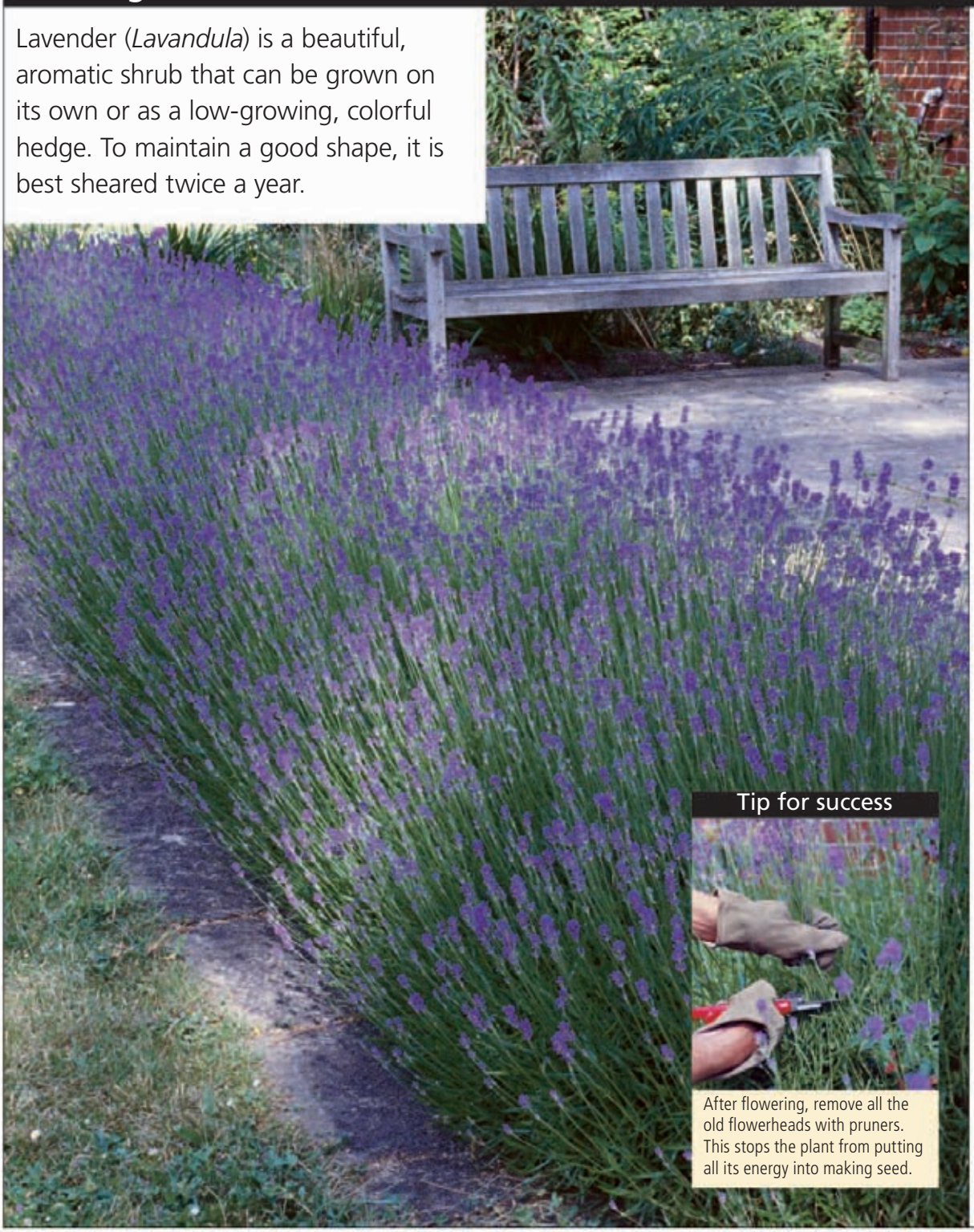






Shearing lavender

Lavender (*Lavandula*) is a beautiful, aromatic shrub that can be grown on its own or as a low-growing, colorful hedge. To maintain a good shape, it is best sheared twice a year.



Tip for success

After flowering, remove all the old flowerheads with pruners. This stops the plant from putting all its energy into making seed.



1 To keep your lavender plants young, bushy, and healthy, cut them back in late winter or early spring using clean, sharp hedge shears.



2 Shear the lavender as close as possible without cutting into the old wood. This is very important because the old wood does not regenerate, which means that if you cut into it, no new shoots will grow from the stems.



3 Here, you can see how the lavender has been cut just above where the new green shoots meet the old, brown wood. Shear to this point, and work systematically along and around the hedge, keeping it as level as possible.



4 This form of pruning encourages the lavender to become very bushy, and to produce a greater volume of flowers. The hedge then needs to be pruned again as the flowers fade in summer (*see Tip for success, opposite*).

How to prune wall shrubs

Euonymus fortunei cultivars are vigorous plants that will grow even in poor soil. They often form rounded shrubs, but will also grow vertically, the variegated forms brightening walls and fences. Prune plants in late spring.



1 As with all variegated plants, it is important to remove any growths that are showing signs of reversion, where stems of all-green leaves appear. Cut these back to variegated foliage using pruners as soon as possible.



2 Using pruners, cut back to a suitable length any very long growths that are hanging away from the wall and causing the plant to lose its neat shape.



3 To keep it neat and bushy, trim over the whole plant with hedging shears. Keep one eye on the overall shape to ensure that you trim it as evenly as possible.



4 Remove any growths that are growing toward or into gutters or over doors and windows. When you are finished, the plant should resemble a closely clipped hedge growing against its supporting wall or fence.

Garrya elliptica is a useful evergreen shrub that produces long, pendulous catkins in the winter. It prefers to grow against the shelter of a wall for support and protection, and is best pruned in the spring, as the catkins are fading.



1 Any plant occasionally needs a trim to stop it from growing too tall or wide. For a shrub trained against a wall, trimming also prevents it from becoming too heavy and pulling or falling away from its support.



2 Start by pruning the longest horizontal branches to reduce the width of the plant. Always make the cuts above a leaf bud or stem shoot to encourage new, fuller growth during the coming year.



3 Once you have trimmed the horizontal branches, start pruning the tall, vertical stems. Cut them back to a height that is appropriate for the position of the plant.



4 If the plant is pruned carefully, it should still retain its natural shape afterward. The new growths that appear as a result of pruning will produce a good show of catkins the following winter.

How to prune a mahonia

When evergreens such as this mahonia have outgrown their allotted space, they can be pruned back severely from midwinter to early spring, after flowering has finished.

Tip for success



To keep plants short and bushy and to encourage greater flower production, remove flowerheads immediately after flowering.



1 Prune back tall stems, removing a little at a time, rather than cutting back the whole growth at once. At this stage, cut the stems to about 2 ft (60 cm) high, keeping in mind the plant's balanced shape as you prune.



2 Once you have cut back the tall growths, look to see where you can make your final pruning cuts. At the same time, remove any damaged, diseased, or crossing stems, and cut out any old growths to leave 5 or 6 strong stems.



3 Cut back the remaining young healthy stems so that they are 12–16 in (30–40 cm) above the ground. If possible, ensure that all the cuts you make are slightly sloping to encourage the rain to run off.



4 Later in the year, a mass of young shoots will grow from these shortened stems. The plant may not flower until two years after a severe pruning like this. Thereafter, to keep it bushy, follow the Tip for success (*see facing page*).

Pruning a holly bush

A well-shaped holly (*Ilex*) can provide a wonderful structural focal point in the garden year-round. To maintain their shape, it is best to prune holly bushes in early spring.

Holly hedge



Holly has thick, chunky growth, so holly hedges are best trimmed in late summer using a gas or electric hedge cutter.



1 To ensure that this young holly remains an attractive feature in the garden, it needs to be pruned annually, first to form a conical shape, and then to retain it.



2 Remove some of the lower branches to create space under the bush and a short, clear stem. This is known as "lifting the skirt" and produces a bolder appearance.



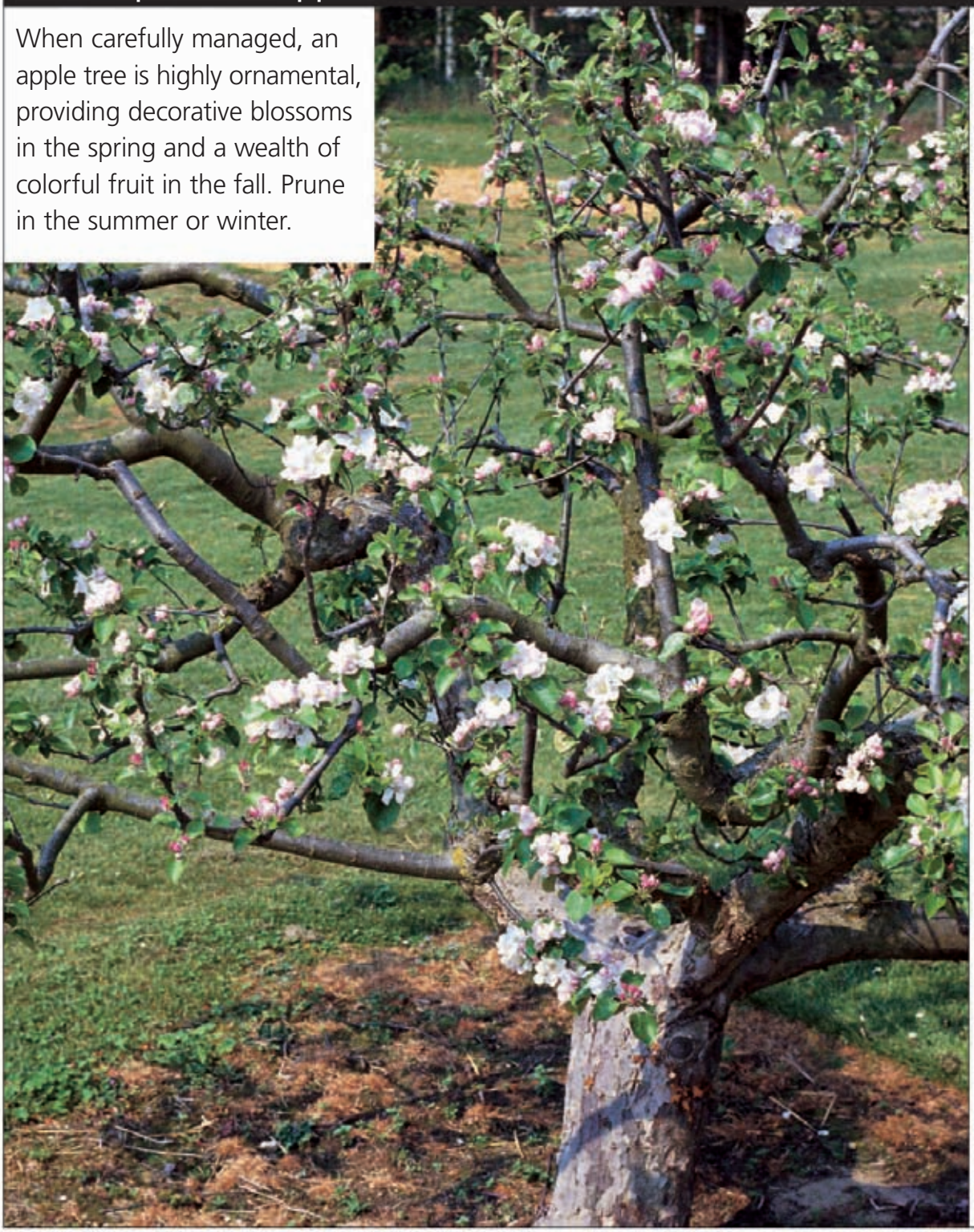
3 If two branches are growing closely together at the top of the plant and causing it to lose its conical shape, cut the weaker one—or the stem that is least vertical—above a shoot that is growing in line with the conical outline.



4 Work all around the bush, trimming back any branches that are too long, until you have a conical shape that is symmetrical and pleasing to the eye.

How to prune an apple tree

When carefully managed, an apple tree is highly ornamental, providing decorative blossoms in the spring and a wealth of colorful fruit in the fall. Prune in the summer or winter.





1 Start by removing any branches that are crowding the center of the tree. This will allow air to circulate, which reduces the risk of fungal infections during the summer. Also remove any dead, diseased, or damaged branches.



2 Cut the branches back to the collar (*see pp.170–171*). Make clean cuts with a sharp saw to reduce the risk of infection entering the wounds. Don't prune too hard, as it stimulates leafy growth at the expense of flowers and fruit.



3 Only reduce the height of the tree yourself if you can reach the top easily. Cut back any long branches by a half to one-third, or to a suitable side branch that, if possible, faces outward, to prevent crossing branches.



4 When pruning back to a side branch, make an undercut first, and saw halfway through the stem. Then make the final cut from above, sloping away from the side branch, to meet the undercut. This prevents the branch from tearing.

How to prune an apple tree *continued*



5 The sloping cut you make after removing a branch (*above*) allows moisture and rainfall to drain off the cut surface, reducing the risk of rotting. The remaining side branch should also point outward.



6 Shorten any long, thin, whippy growths by cutting them back to short branches or spurs with a pair of pruning shears. This encourages flower bud formation from these branches.



7 Where pruning cuts have been made in previous years, remove any short, weak, or crowded stems growing around the wound. These are of no use to the tree and divert energy from the main branches and flower stems.



8 Remove all branches that are crossing or are starting to grow from the outside of the tree into the center. This helps to prevent branches from rubbing against each other in the future, thereby reducing the risk of disease.



9 Continue to work around the tree, removing unwanted branches and taking care to make clean cuts. Step back from the tree to ensure that you have created a balanced, simple framework, with an uncongested center.

How to prune wisteria

Wisterias are beautiful plants for training up house walls and other structures. Prune these large, vigorous climbers twice a year, once in summer to keep the plant in check, and again in winter to help stimulate flowering.



Summer pruning



1 Wisterias are vigorous plants, and during the summer after they have flowered, the plants produce very long tendril-like shoots that can block house windows or paths, or swamp their supporting structures.



2 To keep your wisteria tidy, reduce these shoots by two-thirds after the flowers have faded. This process may have to be repeated several times during the summer months as the plant continues to grow.

Winter pruning



1 In late winter, when the leaves have dropped, you will be able to see the effects of your summer pruning. The pruned stems will have developed new growth, which will look lighter in color than older wood.



2 Spur prune (*see pp.172–173*) all the stems that you pruned in the summer back to two or three healthy buds. These buds will then swell to become flower buds in spring.



3 Also remove any stems that are growing into the eaves of the house, under shingles, or around drain pipes or down spouts. If left, they could cause damage to the house structure.



4 Ensure that all stems are tied to sturdy wires on the house or plant supports, as wisteria is not self-clinging. The plant will look quite bare, but the buds will develop into a wall of scented flowers in late spring or early summer.

Cutting back clematis

Admired for their beautiful flowers, clematis can put on an almost year-round show. They are divided into three groups, each with different pruning needs, so work out which one yours belongs to and follow these guidelines.

Group 1

Group 1 clematis are vigorous plants, and include *C. montana*, *C. alpina,* and *C. armandii*. Flowering in late spring on the previous year's growth, they require very little pruning. Prune lightly immediately after they have flowered to contain their size, and remove any dead, diseased, or damaged growth.



Clematis montana (Group 1)



Clematis "Frances Rivis" (Group 1)

Group 2

This group of early summer-flowering clematis have large flowers that are produced from the previous year's growth. Many will also produce a second flush of flowers in late summer. Group 2 clematis require a light prune in early spring. Prune back stems to a pair of healthy buds.



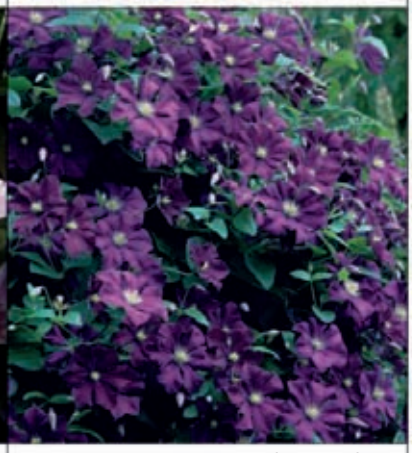
Clematis "Nelly Moser" (Group 2)



Clematis "H.E.Young" (Group 2)

Group 3

Group 3 clematis include the small-flowered viticella and texensis types, *C. tangutica* and its cultivars, and some large-flowered hybrids. They bloom from midsummer to fall on new season's growth and require hard pruning in early spring, or you can prune them more lightly.



Clematis "Etoile Violette" (Group 3)



Clematis tangutica (Group 3)

Pruning after planting

Help all groups of clematis to get established by pruning them after planting in spring, or in their first year immediately after flowering. Reduce the plant's height by one-half, ensuring that you prune above a pair of healthy buds. This encourages the plant to produce growths from all the buds on the stem below the pruning cut, which will ultimately give you a much stronger plant. It also encourages root production, helping to develop strong, healthy growth. Take care when handling any clematis as the shoots can be very brittle.

Pruning Group 1

Immediately after flowering, give Group 1 clematis a light trim to help contain the size of the plant and to keep it looking tidy. Prune strong, leggy new season's growths, cutting above a pair of healthy buds. This will also help to show off the plant's attractive fluffy seedheads, but don't prune too hard or you will remove them. If a plant becomes too large, occasionally prune all stems back to 6 in (15 cm) from the ground in early spring. Montanas may not recover from this treatment, so only carry out drastic pruning if you have no choice.

Pruning Group 2

Prune Group 2 clematis in early spring when the buds are already in growth and new stems are visible. Work from the top of the plant, pruning each stem back to the first pair of healthy buds or growths. Remove any dead, diseased, or damaged wood. New growths will appear along the pruned stems, and these produce the flowers in early summer. If the plant has outgrown its site, hard-prune all stems to 6 in (15 cm) from the ground in early spring. It may not flower during the coming summer, or it may bloom later in the season.



Prune above a pair of healthy buds



Cut away excess growth in spring



Prune lightly back to new growth



New growth soon emerges



Pruning helps to show off seedheads



Buds open below the pruning cuts

How to prune a Group 3 clematis

The late-flowering *Clematis* x *jouiniana* is extremely vigorous, and is suitable for clothing large supports or growing through substantial shrubs or small trees. As it belongs to pruning Group 3, it requires hard pruning in early spring.



1 This clematis has been grown over a large pyramid support made from birch twigs. Start pruning by removing all the loose growths that are covering the support.



2 Once all the stems have been removed from the support, you will have better access to the base of the plant. Prune back all long growths to give a manageable clump of short stems before making your final cuts.



3 Prune the growths hard back to one or two buds from the ground, as shown. Always make straight cuts just above a pair of healthy buds to reduce the risk of dieback.



4 You will be left with a mound of growths about 6 in (15 cm) high. To encourage healthy growth, add a little fertilizer and mulch. The plant will then grow 6–10 ft (2–3 m) and be covered in flowers during late summer.

Lightly pruning late-flowering Group 3 clematis, such as this *Clematis tangutica*, encourages the plant to flower earlier.

Follow these simple steps to create a cascade of beautiful yellow nodding flowers throughout the summer.



1 In early spring and starting at the top of the plant, lightly prune back the main stems to fit the shape of the support. As with any pruning, also remove dead, damaged, or diseased stems as you work.



2 Then lightly prune the side stems back to the plant support. This will maintain the shape of the plant and encourage strong new growths that will flower in the summer. Make sure all cuts are made above two buds.



3 If there are strong young growths coming from the base of the plant, tie them into the rest of the clematis so that they will not blow around in the wind and get damaged—clematis stems are brittle and easily broken.



4 When you have finished, the clematis should look as if it has had a light haircut, since you have just trimmed it back to the shape of the supporting structure.

Cutting back honeysuckle and ivy

Climbing honeysuckles (*Lonicera*) are grown for their beautifully scented flowers. Allow them to scramble over shrubs and trees in the garden, or encourage them to climb up supports, such as fences or trellises.



Climbing honeysuckles are easy to grow, and produce masses of sweetly scented blooms in the summer. As they age, plants can become woody at the base, and look untidy and overgrown. Keep them in check and flowering prolifically by pruning regularly.



1 In spring, contain the size of a honeysuckle by removing long, straggly growths and reducing the overall height of the plant by 12–20 in (30–50 cm).



2 Remove old, dead, damaged, or diseased stems. If your plant is overgrown, cut all the stems back to about 6 in (15 cm) from the ground. New shoots will soon appear from the base, but you may lose the flowers that year.



3 Unless you gave the plant a hard prune, by late summer it will produce an even covering of flowers. If the plant has put on a lot of growth and is looking untidy, trim it again immediately after flowering has finished.

Ivies are versatile evergreen climbers that will grow in sun or shade, and adhere to almost any support or surface. In late spring or early summer, prune these vigorous plants to contain their spread and keep stems from clogging gutters.



1 The aim of pruning here is to reduce the plant's spread over the fence and to remove it from the tree trunk in front. Ivy can collect a lot of dust and dirt, so wear a dust mask when pruning if this affects you.



2 Working from the top of the fence panel, pull away long lengths of ivy. When you are happy with the amount removed, cut off the stems with pruning shears. Also cut away any ivy growing on tree trunks or other plants.



3 Remove ivy growing up walls and into gutters. When removing ivy from walls, you will reveal marks left by the roots, which help the ivy to cling to the surface. Use a stiff brush to remove the root residue.



4 The ivy has been cut back from the top of the fence by about 18 in (45 cm) to allow room for regrowth. It has also been removed from the tree trunk, resulting in a less cluttered and lighter part of the garden.

How to prune a rose on a tripod

Climbing roses, such as this *R.* "White Cockade," can be trained over a wooden tripod to create a lovely focal point in a small space. Prune the rose in the fall or early spring.



Before pruning

The plant is a mass of stems, some of which are old and must be removed, while younger stems need to be tied in.



1 Start by removing the rose stems from the tripod support. Cut all the ties that are holding the rose to the support, and then carefully unwind the stems, working down from the top of the plant.



2 Cut out any dead, damaged, or diseased wood. Then remove about one in three of the oldest stems by pruning them close to the base of the plant. Leave enough stems unpruned to cover the tripod.



3 With the unpruned older stems that you left to cover the tripod, spur-prune the previous season's flowering stems (*see pp.172–173*), and tie them into the tripod. These spurs will produce flowering stems in the coming summer.



4 Tie back the remaining young flexible stems using garden twine. To give the best coverage over the tripod, tie some in a clockwise and others in a counterclockwise direction.

Pruning rambling and climbing roses

Ensure a mass of flowers each year by pruning rambling and climbing roses during the fall while their stems are still quite flexible. If you don't have time in the fall, these roses can also be pruned in late winter or early spring.



1 Remove one in three of the oldest flowering stems. These growths will be quite thick and should be cut back to almost ground level using a pruning saw or loppers.



2 Use sharp pruning shears to spur-prune the previous summer's flowering stems back to two or three healthy buds (*see pp.172–173*). These will then produce flowering stems during the coming summer months.



3 Use garden twine or special rose ties to tie in all the stems. Bending flexible stems over and tying them onto horizontal supports or wires encourages the production of more flowering growths.

Summer maintenance



Do not attempt to prune a rambling rose in the summer. Tie in and support the long, strong new growths that have been produced, so that they are not damaged or broken. These are the stems that you will be cutting back when pruning and training in the fall.

This climbing rose has been carefully pruned and trained along horizontal wires that have been attached to the wall with vine eyes. Place galvanized wire at about 12-in (30-cm) intervals up the wall before planting your rose.



1 Cut all the ties that are holding the rose to the wires and pull the stems away from the wall. Remove one in three of the oldest flowering stems. Do not remove any of the strong new growths produced from the base of the plant.



2 Spur-prune last season's flowering stems back to two or three healthy buds (*see pp.172–173*) to encourage them to produce more flowering stems in the months ahead.



3 Tie all the remaining growths back onto the wires, and try to cover as much of the wall as possible. You may find some of the stems cross over each other, but this won't be a problem as long as they don't rub.



4 Step back from time to time to ensure that you have tied the stems in a fan shape over the wall. By the time summer arrives, the plant will have produced more stems covered in leaves and flowers and the wall will be hidden.

Choosing a site

Growing vegetables in ideal conditions is not always possible, particularly if you have limited space, but it pays to find a sunny spot that is sheltered from the wind and easily accessible for watering and weeding.

Sheltered or sunny walls

A wall that faces the sun provides plants with protection from the wind and reflects the sun's heat back onto your crops during the day. It will also absorb heat and release it at night when the air temperature falls. A sheltered microclimate is ideal for growing heat-loving vegetables, such as tomatoes, eggplants, and peppers, so if you have one in your garden, make the most of it. Improve the soil, create a raised bed, or position pots at the base of the wall. Remember to keep plants well watered.

Tips for sunny walls

- Add supports, such as wire mesh, to the wall to secure tall and scrambling plants as they grow.
- Take advantage of a sunny wall as the perfect backdrop for tomatoes in a growing bag.
- Be adventurous and try growing more unusual crops, such as sweet corn and chili peppers.



A greater range of vegetables can be grown by a sunny wall.

Small vegetable beds

Make the most of a small space by planning your crops carefully and squeezing as much variety into the plot as possible. Many vegetables are attractive plants in their own right, but add extra color to the beds by including some flowers, too, which will not only look good but also help attract pollinating insects. Planting vegetables close together also means that there is little bare soil on which weeds can establish, helping to minimize maintenance, but crop yields may be slightly reduced.

Tips for small vegetable beds

- Densely planted vegetables need rich soil, so work in plenty of organic matter in fall.
- Choose vegetable varieties with interesting colors and forms to add drama to your beds.
- Be wary of planting too close to tall hedges, which cast shade and take moisture from the soil.



Rows of vegetables packed tightly together will suppress weeds.

Growing under cover

Protecting crops from cold and wet weather in a greenhouse, cold frame, or under cloches gives them a head start in spring, extends the growing season into fall, and allows a range of tender vegetables to be grown that may not perform well outdoors. Fitting large structures into a small garden can be difficult, so consider whether you have a suitable site before buying costly equipment. Site greenhouses and frames in full sun, away from overhanging trees, but sheltered from the wind as much as possible. Plants under cover rely on the gardener to provide adequate water and temperature control, which can amount to a lot of work, so make sure you have the time.

Tips for growing under cover

- Control greenhouse ventilation to regulate temperatures and remove damp air that can encourage disease. Automatic ventilation is a good investment.
- Use cold frames and mobile cloches for raising seedlings and protecting young plants.
- Where there is no space outdoors, try sowing seeds and growing heat-loving crops on a sunny windowsill.
- Install a water supply, such as a rain barrel, next to the greenhouse to make life easier.



It is crucial to choose a site in full sun for your greenhouse.

Container growing

Filling pots, troughs, and window boxes with a range of vegetables is one of the best ways for those with little or even no garden to harvest their own homegrown produce. Tomatoes, salads, dwarf beans, herbs, and some root vegetables are just a few of the crops that will thrive in containers and can make attractive displays on patios, steps, and windowsills. Containers filled with good-quality potting mix are also useful in gardens with very poor soil or where soil-borne pests and diseases make vegetable growing difficult. However, containers can be expensive to buy and fill with potting mix, and without regular watering and fertilizing, plants will not perform well, so consider the practicalities before you begin.

Tips for container growing

- Keep costs down and be creative by making your own pots from galvanized metal bins or plastic containers.
- Good drainage is vital to prevent soil from becoming waterlogged, so be sure pots have holes in their bases.
- Choose large pots, as they hold more soil, take longer to dry out, and suit many vegetables well.
- Look for vegetable varieties suited to container growing, such as short, round carrots.



Colorful crops, like this chard, are easy to grow in pots.

Making compost

Every gardener should find space for a compost pile or bin, as it turns garden and kitchen waste into a valuable source of organic matter to dig into soil or use as a mulch.



The final product Compost should be dark brown with a crumbly texture and pleasant, soil-like smell. The decomposition of bulky organic materials requires oxygen, moisture, and the right balance of carbon- and nitrogen-rich waste (*opposite*), which means that careful management is necessary. However, a successful compost pile is easy to achieve.

Different compost bin designs Your first task is to find a compost bin that suits the size of your garden and the amount of waste to be broken down. It is best to have two bins, to allow the contents of one to be aerated by turning it into a second bin, which means that a new pile can be started in the first. The type of bin you choose depends on appearance, space, and cost considerations, but ensure that it has a loose-fitting cover to prevent waterlogging. Place your bin on bare soil, add compostable material, and let nature do the rest.



Wooden bins look good and can be bought or homemade. Choose a design with removable front slats for easy turning.



Plastic bins are relatively cheap and simple to install, but their design means that turning the contents can be tricky.



Bins constructed from wire mesh are particularly suitable for composting fallen leaves to make leafmold.

What goes on the pile? Almost all garden and kitchen waste can be composted, except for diseased material, perennial weeds, and meat and cooked waste, which attracts vermin. Nitrogen-rich (green) waste aids decomposition, but this must be balanced with carbon-rich (brown) waste to open up the structure of the pile and allow air to circulate. Aim to add a 50:50 mix of green and brown waste to your pile during the year.

What to add

- Carbon-rich woody prunings and hedge trimmings (which usually need to be shredded), plant stems, fall leaves, shredded newspaper and cardboard.
- Nitrogen-rich grass cuttings, herbaceous plant material, weeds, vegetable plants, fruit and vegetable peels, tea bags, coffee grounds.



Carbon-rich brown material adds bulk.



Chop up woody material before adding.

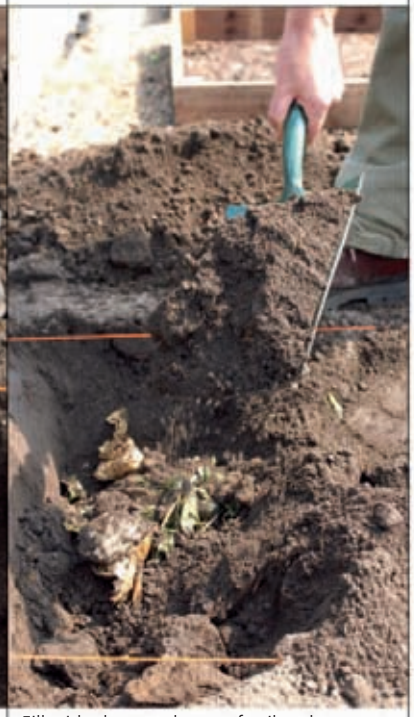
Making a compost trench

Kitchen waste, such as fruit and vegetable peels, tea bags, and eggshells can also be composted in a long trench. The trench is best made during the fall, when large areas of soil are often bare and the waste has time to break down before planting begins in spring. Vigorous plants, such as runner beans and squashes, respond particularly well to the high nutrient levels provided by kitchen leftovers.

Dig a trench about 12 in (30 cm) wide to one spade's depth and fill it with alternate layers of waste and soil. Then add a layer of soil on top. Allow at least two months before planting over the trench. As with any composting method, do not include meat or cooked waste because it may attract vermin.



Scatter waste on the bottom of the trench.



Fill with alternate layers of soil and waste.

Water-wise gardening

Droughts and water metering can cause problems during hot, dry summers, but the solution is to know how to use resources efficiently and to store your own supplies.



Keeping plants healthy Plants in dry soil are susceptible to disease and yield less, so it pays to keep soil moist. Watering thoroughly so the moisture penetrates deep into the soil is better than wetting the surface daily. Water in the evening or early morning to minimize evaporation.

Storing rainwater Water can be collected from the roofs of houses, garages, sheds, and greenhouses, and stored in rain barrels that have spigots at their bases. These supplies of rainwater are a valuable alternative to city water or well water, although during hot summer months, rainfall rarely keeps up with demand.

Rain barrels are often easier to install in a convenient part of the garden than running a hose to the area. Make sure that you set your rain barrel on a stack of bricks, slabs, or a specially made base, to allow a watering can to fit under the spigot. Although many gardeners dislike the appearance of plastic barrels, they are easy to disguise with ornamental planting, such as grasses and bamboo (*right*), or tall rows of runner beans.





Using gray water Water that has already been used in the home is usually suitable for watering plants in the garden. Normal household soaps and detergents do not damage plants, but avoid bleaches and strong disinfectants. Allow hot water to cool before applying it to the soil.



Water the roots Pour water around the stem base, beneath the plant's foliage, so that it is absorbed into the soil around the roots where it is needed. The shade of the foliage also helps to prevent evaporation, and neighboring weeds are not inadvertently watered, too.

Cloches and cold frames

Protect crops from pests and bring on their growth in cold weather by covering them with cloches or growing them in permanent cold frames.

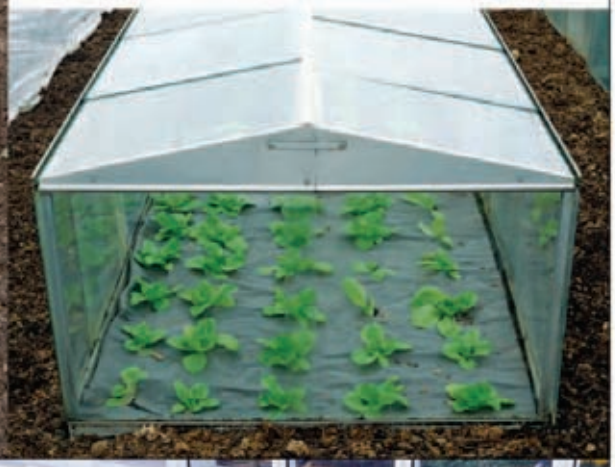


Plastic bottle cloches Many plants benefit from protection in cool spring and fall weather. Commercial cloches can be expensive; large, clear plastic bottles, cut in half and placed over plants, are an effective alternative.



Corrugated plastic cloches Whole rows of plants can be covered using long, low tunnel cloches, which are left open at the ends for thorough ventilation or closed off when greater protection is required. No rain will reach cloched plants, so remember to water them as necessary.

Rigid plastic cloches These large cloches are ideal for protecting blocks of young plants or more substantial crops, such as zucchini or early potatoes. The warm, dry atmosphere is also perfect for drying onion crops after harvest. Anchor these light structures to the ground.



Cold frames Usually permanent structures of brick with framed glass "lights," cold frames are useful for hardening off young plants and extending the productive season of crops such as salads and zucchini. Constructed in a sheltered, sunny spot, they are a good alternative to a greenhouse in a small garden, with the angled glass allowing water to run off and the maximum amount of light to reach the plants. A frame with a hard base is suited to acclimatizing pot-grown plants to outdoor temperatures, while a bed of improved soil allows crops to be grown in the frame. Prop the lights open during the day to provide ventilation, and keep plants inside well watered.



Root crops

Cultivation tips



How to grow Easy to grow, most root crops simply need to be sown outdoors and kept free of weeds and pests to do well. With carefully selected varieties and successional sowing, you can harvest root crops all year.

Site and soil Many root crops like well-drained, slightly acidic soil that holds organic matter, with some nutrients dug in. Potatoes, however, crop best on recently manured soil. Brassica root crops may succumb to clubroot in acidic soil that has not been limed. Stony soil may cause malformation of long-rooted crops.

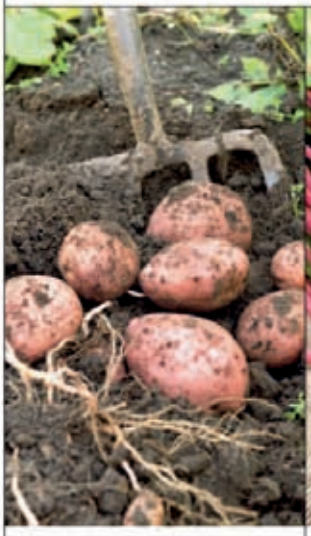
Sowing Most root crops can be grown from seed outdoors from early spring. Sow into drills at a depth of about ¾ in (2 cm) Potatoes need a depth of 4 in (10 cm). Cover with soil and water in. Sow carrots, beets, turnips and radishes every few weeks for a continuous supply.

Care and potential problems Thin seedlings out, leaving strong plants to grow on at the correct spacing. Keep the surrounding soil weed-free and moist, watering in dry spells. Protect potato plants from frost and cover their lower stems and leaves with soil as they grow.

Roots in pots Carrots, beets, and radishes all grow happily in containers at least 10 in (25 cm) wide and deep—larger pots are needed for potatoes—as long as they are kept well watered. This is a good way to start the earliest crops under cover.

Growing potatoes through black plastic If earthing up potatoes sounds like too much effort, try planting your crop through holes cut in a layer of thick black plastic—push the edges into the soil to secure the plastic in place. This keeps out the light and helps warm the soil for a fast-maturing crop.

Crops to choose



Potato Early varieties suit small gardens since they are harvested by midsummer, whereas maincrops tie up the soil until mid-fall.



Beet Not all beets are red, so you can choose unusually colored varieties and opt for bolt-resistant types for early sowings.



Parsnip These roots will stand in the soil through winter with a covering of straw, but seeds need to be sown the previous spring.



Radish Sow radishes successionally for crops over a long season. Exotic hardy winter radishes can also be sown in summer.

Brassicas

Cultivation tips



How to grow Encompassing many of the hardiest winter crops, including cabbages and Brussels sprouts, this group also includes many summer favorites and Asian greens.

Site and soil Moist, well-drained, fertile soil suits most brassicas, so it is best to work in plenty of organic matter well in advance of planting. Lime should be added to soil with a pH lower than 6.8 to prevent clubroot. Brassicas prefer full sun, but will tolerate partial shade, while taller plants, such as Brussels sprouts, need to be staked on windy sites.

Sowing Most brassicas are best sown into an outdoor nursery bed under cover in spring and transplanted into their final positions as young plants. However, sow summer sowings of calabrese and kohlrabi directly into seedbeds in their final positions.

Care and potential problems Brassicas like cool weather and tend to bolt during hot, dry spells. Water transplants daily and mature plants once a week in dry weather. Cover plants with floating row cover to prevent butterflies from laying eggs on them. Slugs, aphids, and whiteflies all enjoy brassicas. Take measures to avoid clubroot.

Thwarting insect pests To keep cabbage maggots and cutworms from destroying young plants, buy protective collars, or make your own. Cut 6-in (15-cm) squares of thick paper, cut a slit, and fit.

Coming back for seconds Broccoli and calabrese continue to produce secondary spears after the central one is cut, and frequent harvesting encourages even more. When harvesting summer cabbages, leave 2-in (5-cm) stumps and cut a cross ½ in (1 cm) deep in the top. This will encourage a second crop to develop.

Crops to choose



Cauliflower Best in rich, heavy soils with plenty of manure. Snap outer leaves over each curd to protect them from sun and frost.



Kale Hardy and tolerant of poor soil, kale is easy to grow. Colorful, textured varieties brighten up the winter garden.



Brussels sprouts Harvest this classic winter vegetable from the base of the stem upward, by snapping off each sprout by hand.



Kohlrabi Eat the swollen stems of these fast-growing exotics in salads or stir-fries. Harvest when no larger than a tennis ball.

Legumes

Pea and bean crops require less fertilizer than other vegetables because their roots are home to bacteria that take nitrogen from the air and fix it in the soil. Leave the nutrient-rich roots to break down in the soil after harvest.



Sugar snap peas ready for harvesting.

How to grow

Site and soil These climbing plants do best in full sun in fertile, slightly alkaline soil, improved with plenty of organic matter. Since they are susceptible to similar pests and diseases, practice crop rotation (*see p.270*). Fava beans prefer clay soil, while other peas and beans do best in lighter soil. Provide shelter from strong winds.

Sowing and planting out All legume seeds need warm soil in which to germinate, so wait until mid-spring to sow outdoors or start them off under cloches or in pots indoors. Successional sowings help to ensure a steady supply of produce. Erect appropriate supports before sowing or planting out to avoid damaging young plants.

Care and potential problems Beans are commonly grown up teepees or rows of canes held together with string; peas scramble up chicken wire supported by canes or twiggy sticks. Beans may need coaxing up and tying into their supports, while peas hold on with tendrils.

Keep plants well weeded, and mulch if possible. There is no need to water before flowering, unless plants are wilting. Begin watering generously when flowering starts, to encourage pods to set. For bushier plants, pinch out growing tips when plants reach the top of their supports.

Rodents love legume seeds, so sow indoors if this is a problem. Protect crops from pea moths with floating row cover. Infestations of aphids are also common.

Harvest and storage Peas and beans are at their tastiest when small and freshly picked, so harvest frequently; this also encourages greater yields. Eating quality deteriorates quickly, even when crops are refrigerated, so either use right away or freeze any excess as soon after harvest as possible. Cranberry beans can be left on the plant to mature, then dried and stored in a cool, dark place.

Sowing depths and spacing

CROP	SOWING DEPTH	SPACING	
		Plants	Rows
Fava beans	3 in (8 cm)	10 in (25 cm)	12 in (30 cm)
French beans, dwarf	2 in (5 cm)	4 in (10 cm)	18 in (45 cm)
climbing	2 in (5 cm)	6 in (15 cm)	18 in (45 cm)
Runner beans	2 in (5 cm)	6 in (15 cm)	18 in (45 cm)
Peas	1½ in (4 cm)	4 in (10 cm)	18–24 in (45–60 cm)

Cultivation tips



Discouraging black aphids on fava beans Black aphids are fond of the young, sappy growth at the tips of fava bean plants. Deter them by pinching out the tips when plants have plenty of flowers and the first pods have set.



Supporting runner beans Climbing French and runner beans need the support of sturdy canes, ideally at least 7 ft (2.2 m) tall, to hold up their lush growth. Teepees of six or eight canes tied at the top are easy to construct.

Crops to choose



Colorful peas With violet flowers and pods, the snow pea 'Ezethas Krombek Blauwschok' adds color to the productive garden.



Fava beans Rarely available fresh in stores, these delicious beans are easy to grow and can be sown in fall for a welcome late spring crop.



French beans Dwarf varieties of this heavy-cropping legume suit the small garden very well. They thrive in pots to yield plenty of gourmet beans.



Cranberry beans Grown in the same way as a climbing French bean, this Italian variety has pink-flecked pods. Eat the beans fresh or use them dried.

Alliums

Cultivation tips



How to grow Alliums include onions, leeks, and garlic. All are strongly flavored and simple to grow in free-draining soil.

Site and soil A sunny, open site with fertile, well-drained soil is ideal for members of the onion family because they are prone to fungal diseases in damp conditions. Treat soil with a pH of less than 6.5 with lime, and don't grow alliums in the same place every year. Manure the ground a few months in advance to stop too much soft growth.

Sowing and planting out All alliums, except garlic, can be grown from seed. Sow in modules in early spring under glass for early crops, or outdoors for later crops. Harden off seedlings and plant out at the desired spacing, or thin direct-sown rows. The final spacing dictates the harvest size of the bulbs. Transplant leek seedlings when they are pencil-size. Drop them into holes 6 in (15 cm) deep and the width of a spade shaft. Water well, but do not backfill with soil. Succession-sow green onions. Onions and shallots can also be planted as sets (and garlic as cloves). Place sets 4 in (10 cm) apart in shallow drills.

Care and potential problems Water onions and shallots in very dry weather. Leeks respond well to regular watering and a mulch. All alliums are susceptible to fungal diseases, including onion white rot, downy mildew, and fusarium. Maintain good air flow around the plants and remove any infected material.

Harvest and storage Harvest leeks and green onions when green, but allow the leaves of onions, shallots, and garlic to yellow and die down before lifting them. Store onions, shallots, and garlic on a wire rack until the leaves rustle; then hang them in a cool, dry place.

Crops to choose



Onions Small or heat-treated onion sets are less likely to bolt and are a good choice for novices wanting a trouble-free crop.



Shallots A single shallot set will divide to produce a crop of several small, sweet bulbs, which are expensive in stores.



Garlic Do not plant supermarket cloves; you will achieve better yields using virus-free stock of cooler-climate varieties.



Green onions A quick, easy onion, ideal for the gaps between slower-growing crops. Try one of the unusual red varieties.

Cucurbits

Cultivation tips



How to grow Vigorous and high-yielding, these plants, which include pumpkins, zucchini, and cucumbers, are great fun to grow. Trailing varieties look good scrambling up a fence or over an arch. Some cucurbits may need hand pollination: female flowers have mini-fruit behind them, while male flowers grow on a thin stem. Remove male cucumber flowers in the greenhouse to prevent pollination and deformed, bitter fruits.

Site and soil Plants in the pumpkin family come from hot climates and thrive on well-drained soil enriched with organic matter. Once established, their growth can be rapid and extensive, so leave them enough space. Cucumbers do well in pots or growing bags.

Sowing and planting out These tender plants cannot tolerate frost and will not grow in the cold. Sow seeds indoors, in biodegradable pots to prevent root disturbance, and plant seedlings out when the weather improves. Harden seedlings off before planting out after the last frost.

Care and potential problems Cucurbits require lots of watering. Cucumbers and squashes often benefit from sturdy supports: cane teepees, fan trellises, and wires in the greenhouse are all effective. Cucurbits are mostly pollinated by insects. Powdery mildew may occur and cucumber mosaic virus can cause deformed fruits. Red spider mite and whiteflies can also be a problem.

Harvest and storage Leave pumpkins, and squashes on the plant until they have a hard skin and cracked stem, and for longer, if possible, if they are to be stored. Cut with a long stem and cure in a warm room for several days, before storing somewhere cool and dry.

Crops to choose



Zucchini Easy to grow and productive, zucchini usually has a bush, rather than trailing, habit, and suits small gardens.



Cucumber The smooth-skinned greenhouse types of cucumbers are more difficult to grow than outdoor ridge varieties.



Summer squash Strangely shaped, soft-skinned squashes taste the same as zucchini and can be cooked in the same way.



Pumpkin A late summer bounty in the garden. Select varieties grown for flavor rather than size if they are for the kitchen.

Fruiting vegetables

These sun-loving crops are a popular choice for patio containers and warm windowsills. There are varieties to suit every size of garden and all kinds of climate, and the right selection will yield delicious late summer crops.

How to grow

Site and soil Provide a warm, sunny site, with light, fertile, well-drained soil for these tender crops. All, except sweet corn, will flourish in containers, in a greenhouse or by a sunny wall. Warm the soil by covering with cloches or clear plastic before planting.

Sowing and planting out Sow crops under cover, at 60°F (16°C) or warmer, in early spring. Where small numbers are required, sow seeds into individual pots of multipurpose potting mix, and cover with sifted potting mix. Keep growing seedlings in a well-lit place. Harden plants off in a cold frame or outside under floating row cover for a week before erecting supports and planting out in the final positions. Pots should be at least 10 in (25 cm) wide and deep. Sweet corn can be direct-sown outdoors in mild areas from mid-spring.

Care and potential problems Water well during flowering and when fruits are developing. Cordon tomatoes need tying into supports, and sideshoots that appear where leaves join the main stem should be pinched out. Pinch out the growing tips of eggplants and peppers to encourage compact growth. When fruits begin to set, apply a liquid fertilizer weekly. Aphids, red spider mites, and whiteflies are common on crops grown under cover, as is botrytis (gray mold). Tomatoes are susceptible to blight, potato cyst eelworm, and viruses. Sweet corn is a favorite with animal pests; mice eat seed in the soil, while birds, squirrels, and raccoons can ruin crops.

Harvest and storage Pick eggplants while the skin is glossy. Uproot outdoor tomatoes and peppers before the first frost and hang in a greenhouse to ripen the last fruits. Check sweet corn for maturity when the silks turn brown by piercing a kernel; white juice shows ripeness.

Sowing depths and spacing

CROP	SOWING DEPTH	SPACING	
		Plants	Rows
Eggplants	½ in (1 cm)	18 in (45 cm)	24 in (60 cm)
Peppers (sweet and hot)	½ in (1 cm)	18 in (45 cm)	24 in (60 cm)
Tomatoes, bush	¾ in (2 cm)	24 in (60 cm)	24 in (60 cm)
cordon	¾ in (2 cm)	18 in (45 cm)	24 in (60 cm)
Sweet corn	1½ in (4 cm)	18 in (45 cm)	18 in (45 cm)



A truss of tomatoes, ripe for harvesting.

Cultivation tips



Watering tomatoes The best way to water tomatoes is to insert a pot, or a plastic bottle cut in half, with holes in the base, into the soil next to each tomato plant and water into it. This delivers moisture directly to the deeper roots and reduces evaporation rates.



Assisting sweet corn fertilization Arrange plants in dense blocks where the pollen will be concentrated, to maximize the yield. These plants rely on the wind to disperse their pollen, and planting in this way encourages the best possible crop.

Crops to choose



Sweet corn These plants look stately in flower beds, and the freshly picked cobs, cooked seconds after harvest, taste terrific.



Sweet pepper Easy to grow, the long, thin-walled varieties of grilling pepper look pretty on the plant and have good flavor.



Eggplant When pinched out to keep them bushy, eggplants make attractive plants for patio pots in warm areas.



Chili pepper Easy to grow, these fiery fruits only ripen reliably under cover. Try them on a windowsill and freeze any excess.

Perennial and stem vegetables

Often disappointing when store-bought, these vegetables are a gourmet treat when freshly picked. They are easy to grow, and perennial types also suit the ornamental garden. The stem vegetables celery and celeriac are not perennials.



Apply fertilizer to asparagus in early spring.

How to grow

Site and soil Choose a sunny, open site, with deep, free-draining soil, and fork in plenty of organic matter before planting. Celery thrives only in very rich, moist soil, so if your soil is poor, you may do better with celeriac.

Sowing and planting out Asparagus and globe artichokes are difficult to grow from seed, so many gardeners start in spring with asparagus crowns and young globe artichoke plants. To plant asparagus, dig a trench 8 in (20 cm) deep and at the bottom make a central ridge with soil; spread the crown's roots over the ridge and cover with soil so that just the tips are showing. Plant globe artichokes in rows, keeping the leaf rosette above the soil. Simply bury Jerusalem artichoke tubers in the soil. Sow celery and celeriac seed indoors from mid-spring and harden off when they have five to six leaves, before planting out. Water plants in well. Self-blanching celery is an easy choice for beginners.

Care and potential problems Jerusalem artichokes may need support. Water and mulch globe artichokes in dry weather. Mulch the asparagus bed with organic matter, and apply fertilizer in early spring and after harvesting. Cut down when growth yellows in fall. Water celery and celeriac weekly, and mulch with straw or compost. Globe artichokes may be attacked by black bean aphids, and Jerusalem types can be invasive, so keep them in check. Fungal rots may affect all crops in wet weather.

Harvest and storage Harvest celery plants whole before the first frost. Celeriac is hardy and best left in the ground until required. Cut asparagus spears about 2 in (5 cm) below the soil surface when they are about 6 in (15 cm) tall. Cut the heads of globe artichokes while still tight. Unearth Jerusalem artichokes as and when required.

Sowing depths and spacing

CROP	SOWING DEPTH	SPACING	
		Plants	Rows
Celery	On surface	10 in (25 cm)	10 in (25 cm)
Celeriac	On surface	12 in (30 cm)	12 in (30 cm)
Asparagus	1 in (2.5 cm)	10 in (25 cm)	12 in (30 cm)
Globe artichoke	n/a	30 in (75 cm)	36 in (90 cm)
Jerusalem artichoke	4 in (10 cm)	12 in (30 cm)	12 in (30 cm)

Cultivation tips



Earthing up celery Trench celery is a traditional garden crop (*see left*). The stems are blanched by covering the stems with soil, known as "earthing up," to exclude light. Tie the stems together with string when the plant is 12 in (30 cm) tall, and pile soil around them to half their height. Repeat every three weeks until just the tops are showing in late fall.

Mulching globe artichokes Globe artichokes, particularly young plants and those growing in cold areas, can be damaged by frost, so protect them during the winter by earthing up around them and covering the plant with a 6-in- (15-cm-) thick mulch of straw, or a double layer of floating row cover.

Harvesting young asparagus plants Patience is a virtue when establishing an asparagus bed. Resist harvesting the spears for the first two years after planting, to allow the plants to gather strength for future years. Harvest for six weeks in late spring in the third year and for eight weeks in the years that follow.

Crops to choose



Celery Self-blanching varieties are best grown close together in tight blocks or cold frames to produce tender, pale stems.



Celeriac This knobby vegetable tastes much better than it looks and is delicious roasted, mashed, or in soups.



Globe artichoke A tall, easy-to-grow decorative plant with silvery foliage. The mature flower buds are a real delicacy.



Jerusalem artichoke The tubers are usually cooked but can be eaten raw. Plants are tall and make a good windbreak.

Salad and leafy vegetables and herbs

Everyone has room for a little pot of herbs or a window box of cut-and-come-again salad leaves. They are so easy to grow that you'll wonder how you managed before without all those fresh flavors on your doorstep.

How to grow

Site and soil Salad crops, chard, and many herbs tolerate most soils, except waterlogged, and don't demand a lot of soil preparation. However, spinach and Asian greens need rich, fertile, nonacidic soil. All do well in containers and full sun, but lettuces need shade in high summer.

Sowing and planting out Leafy salads germinate quickly in warm conditions, but avoid extremes of heat or cold. Sow salads in modules under cover from early spring; sow spinach, Swiss chard, and bok choy outdoors in light shade. Successional sowings of small numbers of seeds help to guarantee a continuous supply of leaves. Plant out module-grown seedlings when their roots have filled the container, and water well. Thin directly sown seedlings to the appropriate spacing.

Tender herbs, such as basil, are often grown from seed; hardy herbs are usually bought as young plants. Sow seeds under cover in early spring; plant out after the last frost.

Care and potential problems Keep rows of salads and leafy crops weed-free and don't let them dry out, to discourage bolting. Protect early or late crops from frost with cloches or floating row cover. Trim herbs regularly to keep them productive; water containers frequently.

Slugs and snails, as well as clubroot and caterpillars on brassicas, are the biggest problems. Lettuces are prone to fungal rots in wet weather; mildew can spoil spinach crops.

Harvest and storage Leafy salads are best eaten fresh. Cut hearting lettuces and bok choy at their base; pick leaves as needed from loose-leaf lettuces, cut-and-come-again crops, spinach, and chard. Use herbs fresh, or dry or freeze them.

Sowing depths and spacing

CROP	SOWING DEPTH	SPACING	
		Plants	Rows
Lettuce	½ in (1 cm)	6–12 in (15–30 cm)	6–12 in (15–30 cm)
Mizuna/mibuna	½ in (1 cm)	4–6 in (10–15 cm)	6 in (15 cm)
Arugula	½ in (1 cm)	6 in (15 cm)	6 in (15 cm)
Spinach	1 in (2.5 cm)	3–6 in (8–15 cm)	12 in (30 cm)
Chard	1 in (2.5 cm)	8 in (20 cm)	18 in (45 cm)
Basil	¼ in (0.5 cm)	8 in (20 cm)	8 in (20 cm)
Parsley	¼ in (0.5 cm)	8 in (20 cm)	12 in (30 cm)
Cilantro	¼ in (0.5 cm)	8 in (20 cm)	12 in (30 cm)



Colorful red-leaved lettuce 'Great Dixter'.

Cultivation tips



Preventing lettuce and spinach from bolting In hot weather and when the soil is dry, lettuces, spinach, and many other leafy crops bolt, which is when plants go to seed and leaves become bitter (*see left*). Prevent or delay this by keeping the soil moist with regular watering and by planting summer crops in light shade rather than full sun.

Halting the spread of mint With its underground runners, mint can become an invasive nuisance in the garden, so it is best to grow it in a container or at least in a pot sunk into the soil. The latter will help to prevent it from taking over, but may not confine it forever.

Propagating perennial herbs Renew the vigor of old woody perennial herbs by digging them up in late summer and dividing them. Using pruners, cut the plants into small sections with plenty of healthy roots and leaves, which you can then replant. This works particularly well for thyme, chives, and oregano, but division is not suitable for shrubby herbs, such as sage and rosemary.

Crops to choose



Spinach A very nutritious crop and easy to grow. Harvest baby leaves to use in salads, or mature leaves for steaming.



Swiss chard This striking crop is grown for its colored stems, which look good on the plate, and can be steamed or eaten fresh.



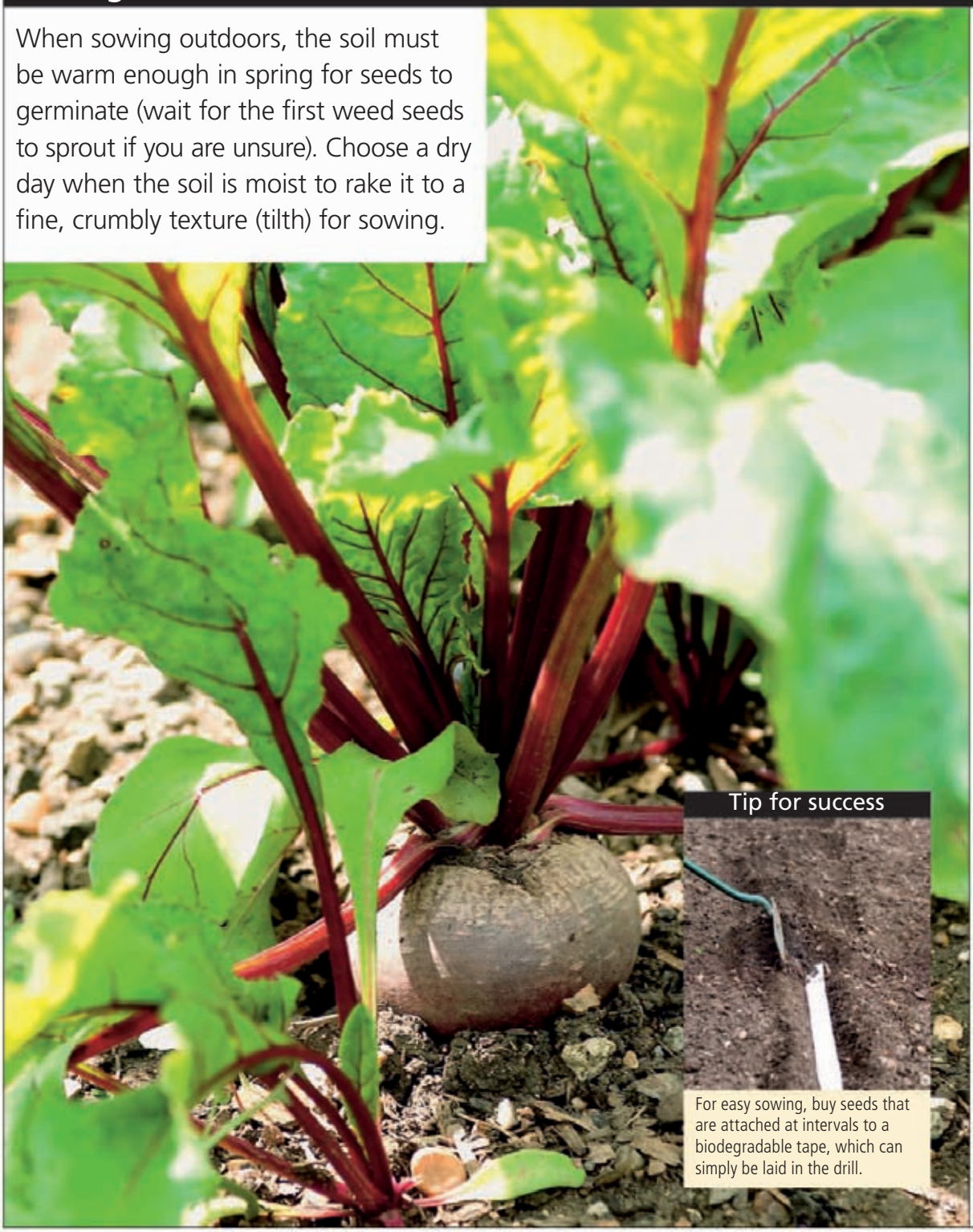
Apple mint Furry, with a mild, sweet flavor, this is the best mint for flavoring vegetables and to stroke as you walk past.



Purple sage This bushy, purple-tinged plant is so attractive that it is often planted in flowerbeds. It tastes good, too.

Sowing beet seeds outside

When sowing outdoors, the soil must be warm enough in spring for seeds to germinate (wait for the first weed seeds to sprout if you are unsure). Choose a dry day when the soil is moist to rake it to a fine, crumbly texture (tilth) for sowing.



Tip for success

For easy sowing, buy seeds that are attached at intervals to a biodegradable tape, which can simply be laid in the drill.



1 For a straight row, pull a string line tight across the seed bed and make a V-shaped drill by dragging the corner of a hoe along the string. Make the drill about 1 in (2.5 cm) deep for beet seeds (the depth varies for different crops).



2 Pour seeds into the palm of your hand and sow them one at a time at 2-in (5-cm) intervals along the row. (Spacings vary for different seeds according to their size; tiny seeds should be sown as thinly and evenly as possible.)



3 As soon as sowing is complete, use the back of a rake to push the soil gently over the drill. Mark the row clearly with a plant label so you know what you have sown where, and don't disturb the germinating seeds.



4 Keep rows free of weeds. Remove excess seedlings by pulling them out with their roots, or pinching them off at soil level when they are large enough to handle. This ensures that the remaining plants have enough space.

Growing zucchini from plug plants



1 Buy compact, green plants with a healthy root system. Water well and plant out or pot on immediately to avoid slowing their growth. Beware of buying zucchini and other half-hardy plants before the risk of frost has passed.



2 Carefully remove each seedling from its packaging and, holding the root ball rather than the delicate leaves, plant them into prepared soil so that the top of the root ball is just below soil level.



3 Gently firm the soil around each plant so that it is stable, and water well to help it get established. Add a mulch of organic material around each plant (but not touching the stem) to retain soil moisture and suppress weeds.



4 Label, and add supports for plants that need them as they grow. Cloches are often useful to protect young plants from cold and windy weather. Continue to water the plants regularly until they are established.

Growing first early potatoes



1 In late winter, place your seed potatoes in egg cartons or trays with the maximum number of buds (eyes) pointing upward. Stand the boxes in a cool, light place indoors for about six weeks to produce sturdy, dark sprouts.



2 When shoots reach about 1 in (2.5 cm) long, in early spring, mark a row in prepared soil. At 12-in (30-cm) intervals, dig holes about 4 in (10 cm) deep and plant a single tuber in each, with its shoots pointing upward.



3 Fill each hole with soil, rake over the row, and mark its position. A general-purpose fertilizer can also be applied at the specified rate on either side of the row at this stage, or it may be worked into the soil before planting.



4 Tubers exposed to light will turn green, making them toxic and inedible. To avoid this, earth up the plants as they emerge by mounding soil around their stems to a height of around 6 in (15 cm).

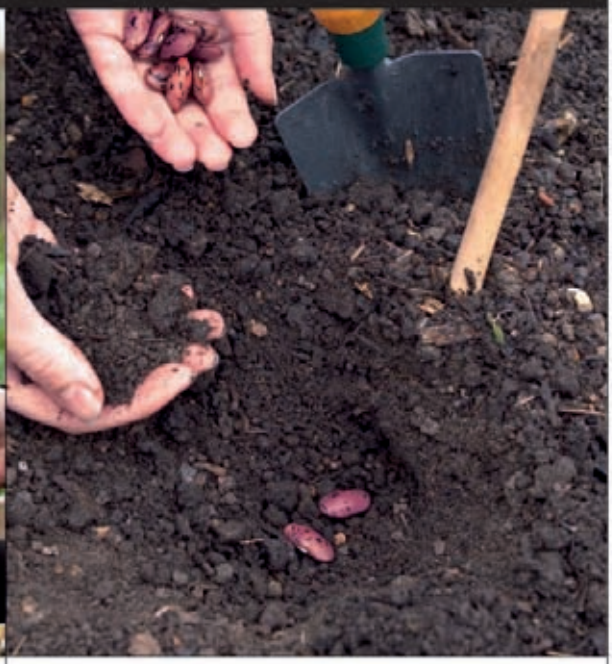
Growing runner beans

Runner beans grow best in rich, fertile soil, so prepare your site by digging in plenty of organic matter at least two weeks before planting. Plant scented flowers, such as sweet peas, nearby to attract pollinating insects to the garden.





1 Support is vital for these climbing plants. Build a teepee from eight canes, ideally at least 7 ft (2.2 m) long, pushed firmly into the soil about 12 in (30 cm) apart, in a circle. Tie the canes securely at the top and again halfway down.



2 From late spring, when the soil is at least 54°F (12°C), plant two seeds at a depth of 2 in (5 cm) by each cane and water thoroughly. In cold areas or where the soil is heavy, sow the seeds in deep pots indoors in mid-spring.



3 After germination, remove the weaker seedling. Twist the remaining plant around its cane and tie it in with twine. A companion sweet pea plant will attract insects to the runner bean flowers, promoting a good crop.



4 It is important to pick runner beans regularly (at least twice a week), when they are young and tender, because overly mature pods are less appetizing and suppress the formation of new flowers.

Planting tomatoes in a growing bag

Growing bags dry out rapidly, but the volume of potting mix can be increased, and the need to water reduced, by planting into open-ended pots inserted into holes in the bag, as shown here.



Tip for success

Other summer crops, such as lettuce, suit growing bags, taking only 8–12 weeks from seed to the cropping stage.



1 Using a knife, carefully cut three openings in the top of the growing bag and cut drainage holes in the base. If using bottomless pots (buy ready-made, or make your own), insert them into the openings and fill with soil.



2 When the plants are hardened off and the first flowers are about to open, plant into the bag or the pots so that the top of the root ball is just below the soil surface. Firm the soil around the roots and water well.



3 Add canes or strong wires for support. Take care to pinch out all fast-growing sideshoots between the leaves and stem—they divert valuable energy away from fruit production. Apply a liquid tomato fertilizer weekly.



4 Tie in the main stems with twine as they grow. Stop the plant from growing taller by removing the growing tip, two leaves beyond the fifth or sixth cluster (truss) of fruit. This diverts the plant's energy into the last fruits of the season.

Growing chard in a container

A large pot filled with the glossy green leaves and neon-colored stems of chard 'Bright Lights' will add color to any patio. Harvest the baby leaves for salads when young, or allow them to mature for steaming and stir-frying.



Tip for success

Test different layouts in your container while the plants are still in their own pots to help create the best color display.



1 Position the empty pot in a sunny, sheltered spot. Ensure that the container has drainage holes, cover the base with a layer of crocks, and add multipurpose potting mix to within about 1 in (2.5 cm) of the container's lip.



2 Water the young chard plants and carefully remove them from their pots, holding them by the roots rather than the leaves. Gently tease out the roots to help them establish quickly, and space them about 4 in (10 cm) apart.



3 Place the plants into holes made in the potting mix at the correct spacing, checking that the top of the root ball is just below soil level. Gently firm soil around each plant and water the container thoroughly.



4 Water the chard regularly to keep the large leaves firm and in good condition, especially during hot summer weather. You can also apply a nitrogen-rich fertilizer to help maintain vigorous healthy growth.

Intercropping lettuce and corn

Planting a slow-growing and a fast-maturing crop together in a grid pattern is an efficient way to make the most of limited space. Lettuces can be grown among sweet corn plants and picked before the cobs mature.





1 Measure and mark out a grid of 18-in (45-cm) squares. Use bamboo canes to mark the lines in the soil. This block arrangement is also ideal for maximizing the wind pollination of sweet corn.



2 Transplant one young corn plant in the corner of each square. Firm the soil around the base of each plant. (Corn plants are tender, so they may have to be raised from seed under cover, *see p.217.*)



3 Mix the lettuce seed with fine sand and scatter thinly in between the corn plants. Rake over carefully. The lettuces will mature in 8–12 weeks and fill the gaps in between the corn plants.



4 Thin the lettuce seedlings to 3–4 plants per square. Sweet corn takes at least 16 weeks to produce mature cobs, but the lettuce can be harvested long before the corn casts too much shade on them.

Planting an herb garden

This formal herb feature takes only a day to build and a season to mature. Here, bricks have been used to edge the beds and divide them into quarters. A potted bay tree forms the centerpiece.





1 Mark out a cross with pegs and string. Dig trenches following the string lines, just wider and not quite as deep as the bricks to allow space for the bricks to settle. Use a hammer handle to firm in the bricks.



2 Finish the last quarter and bed the bricks down securely, packing the soil firmly against them (no need to mortar them in). If you wish to have a plant in the center of the feature, make sure you leave space for it.



3 Arrange the plants in their pots before they go in the ground, so you can adjust the spacing if required. Water each plant thoroughly before removing it from its pot. Make planting holes and insert the plants. Water well.



4 Finish off the design with a central plant—a bay tree, which can be clipped into shape, has been used here. Water all the plants regularly until they are fully established, especially in hot, dry weather.

Vertical vegetable garden

Vertical space is often underused, but it has great potential in small gardens, increasing the space for growing a range of crops. Attaching pots of herbs and bush varieties of vegetables to a sturdy wire mesh can turn a bare sunny wall into a riot of color, and they are simple to care for and convenient to harvest. Vigorous climbing beans, squashes, and nasturtiums can be planted in large containers at the base of the wall and are easy to train up the mesh for a fabulous, lush display.

Garden basics

Size 6 x 7 ft (1.8 x 2.2 m)
Suits Any sunny location with a wall or fence as a backdrop
Soil Light, multipurpose potting mix
Site Wall in full sun

Shopping list

- 2 x eggplant 'Mohican'
- 3 x basil 'Sweet Genovese'
- 3 x basil 'Red Rubin'
- 3 x tomato 'Tumbling Tom Red'
- 1 x cucumber 'Masterpiece'
- 1 x zucchini 'Tromboncino'
- 3 x runner bean 'Wisley Magic'

Planting and aftercare

Attach wood battens to the wall and secure a sturdy wire mesh to them. Drill holes in the sides of plastic pots and window boxes and thread galvanized wire through them before planting. After the risk of frost has passed, fill the pots with a lightweight potting mix, plant with hardened-off plants, secure pots to the mesh, and arrange larger ones at the base of the wall. Leave space for plants to develop, and train climbing crops up the mesh. Water the plants frequently because they will dry out rapidly in their exposed position. Tie in climbing plants as they grow, and harvest frequently to encourage further crops.



Eggplant 'Mohican'



Basil 'Sweet Genovese', 'Red Rubin'



Tomato 'Tumbling Tom Red'



Cucumber 'Masterpiece'



Zucchini 'Tromboncino'



Runner bean 'Wisley Magic'



Hanging herb and vegetable basket

Vegetable gardening does not get much more convenient than picking juicy cherry tomatoes and fragrant herbs from just outside your back door. Hanging baskets are often associated with bedding plants, but why not try planting a combination of cascading cherry tomatoes, vibrant nasturtiums, and delicious herbs instead? Kept fertilized and watered, they will look great over a long season and provide tasty fresh produce for the kitchen as well.

Container basics

Size Basket at least 10 in (25 cm) in diameter
Suits Area close to the kitchen
Soil Multipurpose potting mix
Site Wall in full sun and sheltered from strong winds

Shopping list

- 1 x chocolate peppermint 'Chocolate'
- 1 x parsley 'Forest Green'
- 1 x lemon thyme 'Golden Lemon'
- 1 x tomato 'Tumbler'
- 1 x chives
- 1 x nasturtium 'African Queen'

Planting and aftercare

Ensure that drainage holes have been made in the base of the basket. Place a layer of lightweight potting mix in the bottom of the basket, then position the plants, still in their pots, to see where they will look best. Remember that trailing plants should be near the edge. Once you have settled on a design, water the plants well, remove them from their pots, and place in the basket. Fill the gaps with potting mix, firming around the plants, and water the basket thoroughly. Hang it on a sturdy hook and water regularly. Once tomatoes begin to set, apply a liquid tomato fertilizer weekly.


Peppermint 'Chocolate'


Parsley 'Forest Green'


Lemon thyme 'Golden Lemon'


Tomato 'Tumbler'


Chives


Nasturtium 'African Queen'



Cut-and-come-again window box

Even without a garden, it is possible to grow a good supply of tasty baby salad leaves. Cut-and-come-again salads are one of the quickest and easiest crops to grow from seed and, when grown in a window box, could not be more convenient to care for and harvest. Try growing your own mix of lettuce, Asian greens, and arugula to create a peppery salad, which tastes wonderfully fresh when it has gone from plant to plate in a matter of seconds.

Window box basics

Size 20 x 6 in (50 x 15 cm)
Suits Window sill where a window box can be secured
Soil Good multipurpose potting mix
Site Window sill with access for watering, in full sun or partial shade

Shopping list

- 1 x packet mibuna seeds
- 1 x packet mizuna seeds
- 1 x packet lettuce 'Oakleaf' or 'Salad Bowl Mixed' seeds
- 1 x packet arugula seeds

Planting and aftercare

Choose a window sill in sun or partial shade, which can be reached easily for watering and harvesting. Make sure the window box is secured and has drainage holes in the base. Add a layer of crocks to the box and fill it to within ¾ in (2 cm) of the top with multipurpose potting mix. Blend the different seeds together in a bowl and sow thinly from the palm of your hand from mid-spring until late summer. Cover with a thin layer of potting mix and water well. Germination is rapid and the first leaves can be cut with scissors after 3–5 weeks, leaving a 2-in (5-cm) stump to regrow. Two or three further harvests can be cut at 3–5-week intervals. Water the window box regularly for a healthy crop.



Mibuna



Mizuna



Lettuce 'Oakleaf'

Additional plant idea



Arugula 'Rocket Wild'



Decorative climbing display

Few flower and vegetable combinations could be more eye-catching than this mix of exotic purple blooms and bulging orange squashes. The vigorous growth of squash is perfect for training up a fence and provides an interesting contrast to the delicate foliage of the climbing passion flower and cup-and-saucer plants. All of these plants flourish in summer heat, and will perform best in warmer areas with a long growing season.

Border basics

Size 6 x 6 ft (2 x 2 m)
Suits Vegetable or ornamental garden with a fence or trellis as a backdrop
Soil Fertile, moist, but well-drained
Site Border in front of fence or trellis in full sun

Shopping list

- 1 x squash 'Uchiki Kuri' or 'Jack Be Little'
- 1 x passion flower (*Passiflora caerulea*)
- 1 x cup-and-saucer plant (*Cobaea scandens*)

Planting and aftercare

Sow squash and cup-and-saucer plant seeds under cover in mid-spring, in either a warm room or a heated propagator. Passion flowers are readily available as plants and will persist as perennial climbers in warm regions. Attach wires or trellis to a bare fence, so the climbing plants can be tied in or use their own tendrils for support.

After the last frost date, plant the young plants about 12 in (30 cm) away from the base of the fence, about 18 in (45 cm) apart, and water them well. Tie the stems to the supports when they are long enough, after which the passion flower and cup-and-saucer plant should find their own way, while the squash may need further tying in. Water the squash regularly once fruits have formed.



Squash 'Uchiki Kuri'



Passion flower (*Passiflora*)



Cup-and-saucer plant (*Cobaea*)

Alternative squash



Squash 'Jack Be Little'



Exotic vegetable raised bed

If you have a sheltered, sunny wall that absorbs the sun's heat during the day and warms the surrounding air at night, take advantage of this microclimate to grow exotic crops. This raised bed has been filled with heat-loving tomatoes, peppers, eggplants, and feathery-leaved garbanzo (chickpea) plants, as well as cucumbers and sweet potatoes that scramble up the wall. Some of these vegetables only crop well in hot summers, but they make attractive curiosities that are fun to try.

Border basics

Size 6 x 3 ft (2 x 1 m)
Suits Any style of garden
Soil Fertile, moist, but free-draining
Site Border in front of a wall in full sun, in warm regions

Shopping list

- 1 x eggplant 'Moneymaker'
- 1 x cucumber 'Carmen'
- 1 x sweet pepper 'Gypsy'
- 1 x tomato 'Summer Sweet'
- 1 x garbanzo 'Principe'
- 1 x sweet potato 'Beauregard'

Planting and aftercare

Sow seeds of tomatoes, cucumbers, sweet peppers, and eggplants under cover in spring. Once the risk of frost has passed, harden the young plants off and plant them out in the raised bed. It is a good idea to soak the garbanzos in regularly changed water for a few days until they sprout before planting them in their final positions. Plant the sweet potato "slips" with about 2 in (5 cm) of stem above the soil and, as with the other young plants, water well. Attach wire mesh to the wall and train the cucumber and sweet potato stems through it. Once the first fruits have set, fertilize weekly with a tomato fertilizer that is high in potash. Crops should be ready to harvest in late summer.


Eggplant 'Moneymaker'


Cucumber 'Carmen'


Sweet pepper 'Gypsy'


Tomato 'Summer Sweet'


Garbanzo 'Principe'


Sweet potato 'Beauregard'



Courtyard vegetable garden

Even a modest corner of the garden can be enough to grow an interesting range of vegetables that will crop well over a long season. Here, cordon tomatoes and runner beans have been trained up the wall and fence to make the best use of the vertical space. Edging the path is a densely sown crop of cut-and-come-again lettuce. Red cabbage and sweet corn will extend the harvest into late summer and early fall, the zucchini in the pot until mid-fall.

Border basics

Size 12 x 6 ft (4 x 2 m)
Suits Courtyard garden
Soil Fertile, moist, but free-draining
Site Corner of garden, sheltered by a wall or fence, in full sun

Shopping list

- 3 x tomato 'Gardener's Delight'
- 3 x runner bean 'Liberty'
- 1 x zucchini 'Burpee's Golden'
- 9 x sweet corn 'Swift'
- 1 x packet lettuce seed 'Salad Bowl Mixed'
- 3 x cabbage 'Marner Early Red'

Planting and aftercare

Prepare the area by digging in plenty of organic matter, ideally in fall. Buy plug plants or, where there is space under cover, sow tomato, runner bean, red cabbage, and sweet corn seeds in pots, harden them off, and plant out after the risk of frost has passed. Plant tomatoes in a growing bag because they thrive on the rich soil, adding canes for support and pinching out sideshoots as they grow. Give the runner beans wires to climb up. Plant sweet corn in a block to aid pollination, and direct-sow a few lettuce seeds regularly to ensure a continuous crop. Water young plants in, and continue watering and fertilizing regularly those in growing bags.



Tomato 'Gardener's Delight'



Runner bean 'Liberty'



Zucchini 'Burpee's Golden'



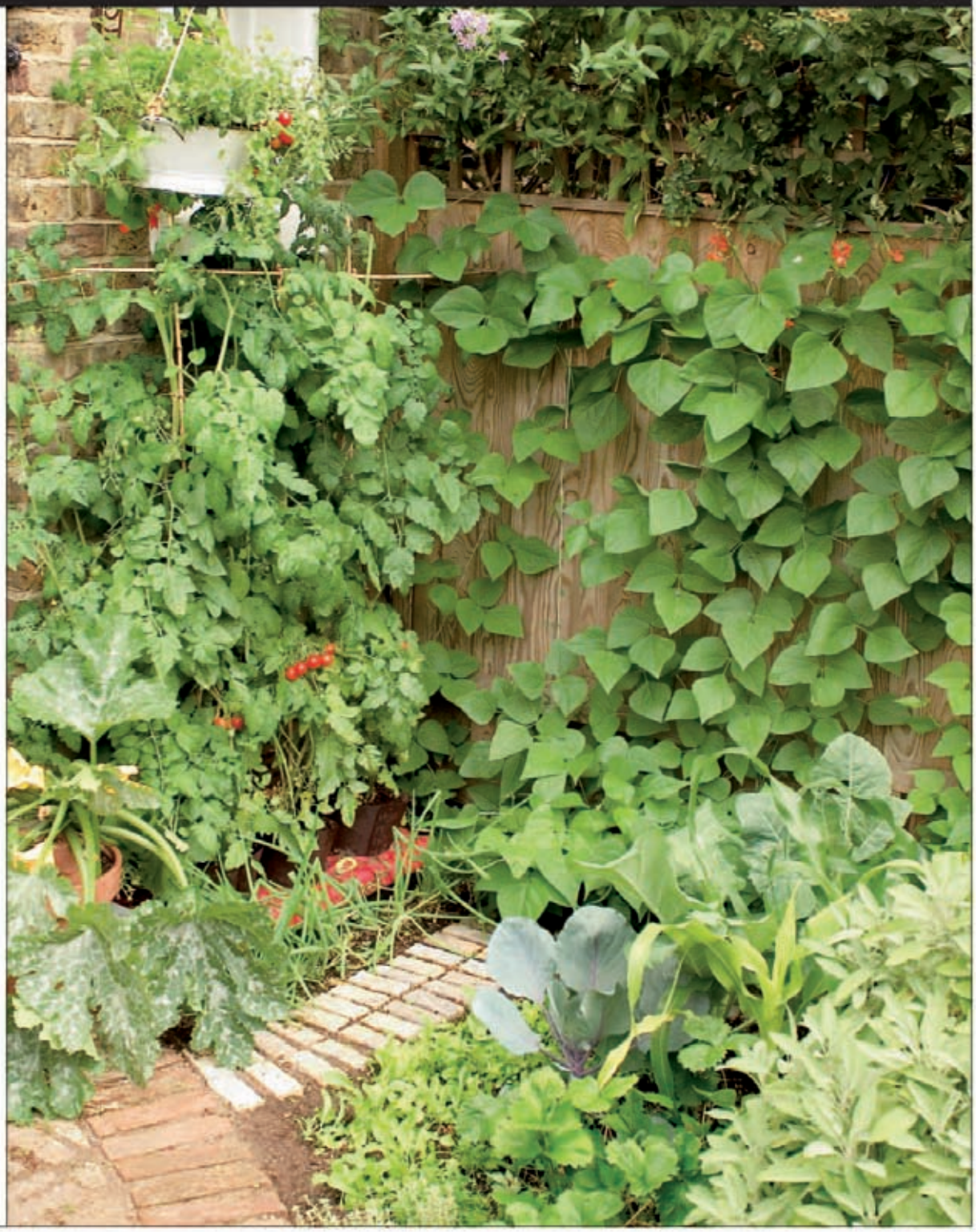
Sweet corn 'Swift'



Lettuce 'Salad Bowl Mixed'



Cabbage 'Marner Early Red'



Pretty potager

Formal patterns and exquisite color combinations characterize the French-style potager, where vegetables look as attractive as ornamental plants.

Planting a potager is not difficult, but it does require careful planning to select and arrange colored varieties that mature to provide interest throughout the year. Here, sweet corn and runner beans add valuable height to a scheme dominated by gray and purple foliage.

Border basics

Size 20 x 25 ft (6 x 8 m)
Suits An area with easy wheelbarrow access and a water supply
Soil Fertile, moist, and free-draining
Site Large open plot in full sun, with shelter from strong winds

Shopping list

- 1 x packet runner bean 'Liberty' seed
- 1 x packet sweet corn 'Lark' seed
- 1 x packet cabbage 'Red Jewel' seed
- 1 x packet fava bean 'The Sutton' seed
- 1 x packet kale 'Red Russian' seed
- 1 x pack shallot 'Golden Gourmet' sets

Planting and aftercare

Prepare the soil by adding plenty of well-rotted manure the fall before planting. Draw out your design on paper, calculating the number of plants required to fill each row and what they can be replaced with once harvested. Plant the seeds in spring, harden off where required, and transplant into neat rows in early summer, adding supports for the runner beans. Water the young plants well, tie climbers to supports, and protect from pests as necessary. Harvest crops as they mature and plan to have replacement plants ready to fill the empty ground as soon as possible to maintain the garden's appearance.



Runner bean 'Liberty'



Sweet corn 'Lark'



Cabbage 'Red Jewel'



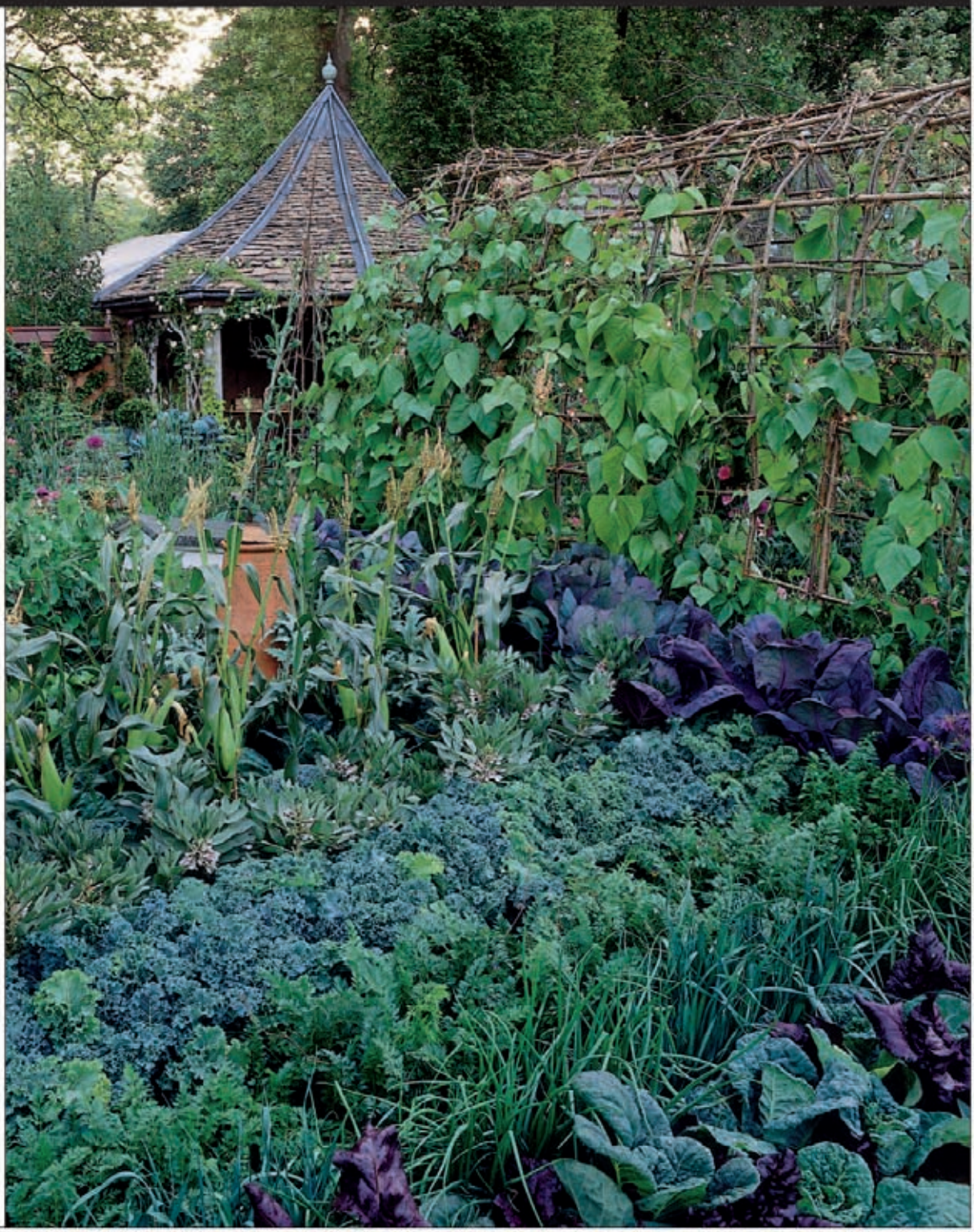
Fava bean 'The Sutton'



Kale 'Red Russian'



Shallot 'Golden Gourmet'



Garden allies

Some wild creatures help to pollinate plants, break down compost, and prey on pests, so make these friendly visitors welcome in your garden.



Busy bees The flowers of many vegetables, such as runner beans, need to be pollinated by insects in order to set their crop. Bees are excellent pollinators, so include ornamental flowers in your vegetable garden to entice them in.

Friendly pest predators

Not all insects found in the vegetable garden are pests, and many of them prey on harmful insects that can destroy entire crops if left unchecked. It is, therefore, well worth encouraging the good guys into your vegetable garden to try to achieve a natural balance and keep pest numbers low. Remember, too, that many pesticide sprays, even organic ones, kill beneficial insects as well as pests, and are best used only as a last resort.



Hoverflies Sometimes mistaken for bees, adult hoverflies are great pollinators, while the larvae feed voraciously on insect pests.



Ladybugs The adults are familiar friends, but the less appealing larvae enjoy nothing better than feasting on juicy aphids.



Lacewings The delicate appearance of the adult lacewing belies the enormous appetites of its larvae for common garden pests.

Helpful animals and birds

Although they may be elusive, many larger garden residents, such as birds and toads, can be a gardener's best friend, feeding on slugs and all kinds of other unwelcome visitors. Birds soon flock to gardens where food is provided, and different species will pick off insects and even feed on snails during a visit. Create suitable habitats for all kinds of creatures and they will repay you with a healthier and more productive garden.



Song thrushes These birds break snails from their shells, so plant a berry-bearing shrub or tree on your patch to give them winter food, too.



Brandling worms Smaller and redder than the usual earthworm, these creatures rapidly reduce vegetable matter to compost.



Frogs and toads Even a small pond can become home to a number of frogs and toads, which will help to keep the slug population in check.

Gallery of weeds

Perennial weeds



Field bindweed (*Convolvulus arvensis*) This climber, with its pretty white flowers and heart-shaped leaves, will regrow from the tiniest fragment of root and quickly spread.



Bramble (*Rubus*) A scrambling shrub, with long, arching, prickly stems, that can rapidly become invasive and hard to remove. The stems also re-root at the tips.



Creeping buttercup (*Ranunculus repens*) This low-growing plant with yellow flowers spreads by runners that form a dense mat of shallow roots, which are relatively easy to remove.



Couch grass (*Agropyron repens*) This leafy grass spreads incredibly fast by tough, underground roots that can be hard to dig up intact. It will regrow from any pieces left in the soil.



Dandelion (*Taraxacum officinale*) Catch the rosettes of toothed leaves while small and easy to remove—once the taproot grows and the seeds disperse, the job is much harder.



Dock (*Rumex*) Large pointed leaves and tall flower spikes grow above a fleshy taproot that extends deep into the soil and takes considerable effort to remove once established.



Ground elder (*Aegopodium podagraria*) The creeping roots make this a pernicious garden weed, easily recognized by its elderlike leaves and clouds of white flowers.



Stinging nettle (*Urtica dioica*) The coarse, jagged leaves are covered with stinging hairs. The bright yellow, creeping roots are easy to see, but a challenge to remove.



Horsetail (*Equisetum*) Almost impossible to eradicate, the dark brown, bootlace-like roots of these feathery plants can extend several yards (meters) underground.

Annual and biennial weeds



Annual meadowgrass (*Poa annua*) This insignificant-looking, low-growing grass colonizes any available space, including cracks in paving, so remove it before it sets seed.



Ragwort (*Senecio jacobaea*) The yellow daisy flowers of this tall plant are produced in its second year, followed by fluffy white seeds that colonize open ground.



Common chickweed (*Stellaria media*) Rather delicate, with charming little white, starlike flowers, this weed establishes and sets seed rapidly, and its sprawling habit smothers seedlings.



Groundsel (*Senecio vulgaris*) The white fluffy seeds of this weed float on the breeze, so it can spread far and wide. Remove plants before the tiny yellow flowers mature.



Shepherd's purse (*Capsella-bursa pastoris*) A rosette of cut-edged leaves gives rise to a spike of small white flowers, which quickly form heart-shaped seed capsules.



Hairy bittercress (*Cardamine hirsuta*) Best pulled up as a seedling, when it has small, watercress-like leaves, because the flower stem rapidly forms long seed pods.



Cleavers (*Galium aparine*) This scrambling weed is covered with little hooked bristles that enable it to climb through plants. Uproot it rather than pulling the stems.



Fat hen (*Chenopodium album*) The gray-green, diamond-shaped leaves of this common weed are easily recognized. It quickly grows tall, with a loose flower spike at its tip.



Plantain (*Plantago*) Low-growing rosettes of almost leathery leaves turn up in beds, paving, and lawns. Remove them before the little bottlebrush flowers are produced.

Dealing with pests

Every garden has its share of pests, so don't panic and reach for the insecticide spray at every sighting. Healthy plants can usually tolerate them, and some are also food for beneficial insects, which you can encourage into your garden.

A healthy balance Help plants stay healthy by providing plenty of water and rich, well-drained soil, and prevent a buildup of pests by planting each crop in a different part of the garden every year. Encourage beneficial creatures, such as birds, hoverflies, and frogs, with suitable food and habitats. This helps achieve a natural balance, where predators keep pest numbers at an acceptable level, and there is less need for chemical intervention.

Control strategies Check plants regularly and pick off any unwelcome arrivals immediately. If you anticipate a problem, put a barrier, such as floating row cover for carrot flies, in place, or grow companion plants alongside the crop to entice beneficial insects or confuse pests. If necessary, use chemical sprays in the evening when bees and other beneficial insects are not flying. Sticky sheets are useful in the greenhouse, as are biological controls, which introduce a predatory organism to kill the pests.



Sticky sheets in the greenhouse help to control airborne pests.

Keeping out animal pests

Large animal pests can devastate a vegetable patch overnight, so where you anticipate a problem, the best way to stop them from reaching your plants is to create a physical barrier. Deer and rabbits need fences to keep them at bay, but there are a number of cheap and easy ways of outwitting slugs, snails, mice, and birds.

- Halved plastic bottles with copper tape around the base protect young plants from slugs, snails, and birds.
- Netting supported with canes or wire keeps out birds; a fine net separates egg-laying butterflies from brassicas.
- Tightly secured netting deters burrowers like rabbits (*see opposite*), which eat roots, brassicas, and peas.



Plastic bottles and copper tape deter slugs.



Prevent bird damage with netting.



Floating row cover keeps out carrot flies.

Gallery of pests



Aphids Sap-sucking insects (greenflies, blackflies) weaken growth and carry diseases. Encourage birds and insect predators, pick off small groups, or use a suitable insecticide.



Rabbits Keep these voracious vegetable eaters out of the garden with a small-meshed fence that extends 1 ft (30 cm) underground to prevent them from burrowing in.



Carrot flies Cover crops with floating row cover, sow carefully to reduce the need for thinning, or grow resistant varieties to prevent carrot fly larvae from tunneling into roots.



Potato cyst eelworm These microscopic, sap-sucking nematodes cause potato leaves to discolor and die. Avoid replanting the same crop where an infestation has occurred.



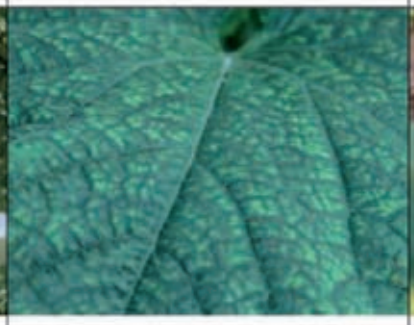
Caterpillars Different parts of various plants may be damaged by caterpillars. Pea moth caterpillars (*above*) live inside the pods. Net crops to exclude egg-laying adults.



Flea beetles These tiny black beetles eat holes in the leaves of brassicas, turnips, radishes, and arugula. Keep them at bay by covering seedlings with floating row cover.



Whiteflies Treat greenhouse whitefly with the biological control *Encarsia formosa* (parasitic wasp), and the brassica whitefly with a suitable insecticide.



Red spider mites Small mites cause mottling on leaves, particularly in the greenhouse. Mist plants to increase humidity, and use the predatory mite *Phytoseiulus persimilis*.



Slugs and snails Protect vulnerable plants, and try beer traps and flashlight hunts. Nematode biological controls are less harmful to other animals than slug pellets.

Dealing with diseases

Just like people, strong, healthy plants are more able to fight off infection than weak, malnourished ones. Here's how to keep yours in shape.

Prevention is better than cure Good cultivation is as much a part of fighting diseases as recognizing and treating them, and with few fungicides available to the amateur, preventative measures are essential.

Plants require a ready supply of nutrients and water to sustain healthy growth, so add plenty of organic matter to the soil to release nutrients and help retain moisture. Additional watering may also be needed, particularly in hot weather. It is important not to forget plants under cover and in containers, which rely on regular watering and feeding to sustain them. Damp conditions and poor air circulation can encourage fungal problems, such as damping-off of seedlings, so use free-draining potting mix and provide good ventilation when sowing indoors.

A neat garden also helps to keep diseases at bay. Ensure that sources of infection, such as dead leaves, harvested plants, and nearby weeds, are removed at the first opportunity. Burn or discard any diseased material; don't compost it because infection could spread.

Although not easy in a small garden, it is advisable to practice crop rotation, where related groups of crops are grown together and moved to a new bed each year, helping to prevent the buildup of diseases in the soil. Where diseases are known to be a problem, try growing resistant varieties. Be aware that plants brought into your garden can introduce disease, so check any purchases or gifts carefully before planting.

Deficiency, not disease Signs of nutrient deficiency, such as yellowing leaves and blossom end rot on tomatoes and peppers, are often mistaken for diseases. Learn to recognize these disorders, so that you can act quickly and minimize their effects. Sometimes the remedy is as simple as improving the water supply; other problems may need fertilizer added to the soil.



Use fresh seed starting mix and new or sterilized pots and trays to prevent damping-off disease.



Keep the garden well watered to encourage vigorous, healthy growth that is less susceptible to all kinds of infection.



Add lime to acidic soil before planting brassicas to increase the pH level and reduce the incidence of clubroot.

Gallery of diseases and disorders



Potato/tomato blight Brown patches on leaves, fruits, and tubers, caused by a fungus that thrives in warm, wet weather. Grow resistant varieties or spray with copper-based fungicide.



Sclerotinia Fungus that causes brown, slimy rot with fluffy, white growth, predominantly on stems and fruits of various vegetables. Remove and burn or discard affected plants.



Magnesium deficiency Older leaves of various vegetables show yellowing between veins, especially in acidic soil or after heavy rains. Apply Epsom salts to the soil or as a foliar spray.



Clubroot This soil-borne slime mold infects brassicas, causing swollen roots, wilting foliage, and even death. Ensure good drainage, add lime to acidic soil, and choose resistant varieties.



Blossom end rot Dry conditions affect calcium uptake, which causes sunken, black patches at the tips of tomatoes and sweet peppers. Correct with adequate, regular watering.



Powdery mildew A wide range of crops are affected by these fungi, causing powdery white growth on leaves in dry soil conditions. Water the soil well, but not over the leaves.



Onion white rot This fungus persists in the soil for up to seven years and causes fluffy white growth on bulbs and roots and yellowing of leaves. Remove and burn infected plants.



Rust Orange or brown spots appear on the leaves and stems of various vegetable crops, particularly in damp weather. Remove infected leaves and grow resistant varieties.



Botrytis A fluffy, gray mold (or whitish spots on tomatoes) that enters plants through wounds or flowers. Remove dead and infected plant material to reduce risk of infection.

Tall plants for sun (Ab–Cy)

Abutilon *x* suntense
This spectacular evergreen shrub is a fine choice for a sunny, sheltered site by a wall or fence. The hairy, gray-green leaves are shaped like those of a grapevine. In late spring, clusters of large, open, purple or white flowers cover the plant for many weeks.

H: 12 ft (4 m), **S**: 6 ft (2 m)
❄❄ ◊ ☼



Acacia dealbata
Reaching tree-sized proportions, this quick-growing evergreen has fernlike, sea green foliage. In sheltered spots, it produces scented, puffball-shaped, yellow flowers in late winter. If it grows too large, it can be pruned to size in spring.

H: 50 ft (15 m), **S**: 20 ft (6 m)
❄❄ ◊ ☼



Arbutus unedo
The strawberry tree is one of the best evergreen trees for a small garden. Shrubby when young, it has glossy, dark green leaves and bell-shaped, white or pink flowers in late fall, followed by strawberry-like fruits. The bark is reddish brown.

H: 30 ft (10 m), **S**: 20 ft (6 m)
❄❄❄ ◊ ☼





Betula utilis *var.* jacquemontii
With its light canopy and slender form, this silver birch suits small sites well. In winter, the dazzling white trunk with its peeling bark provides interest; catkins and young leaves are an attraction in spring. The leaves turn butter yellow before falling.

H: 50 ft (15 m), **S**: 23 ft (7.5 m)
❄❄❄ ◑ ◊ ☼ ☼



Buddleja davidii '*Dartmoor*'
Buddlejas are easy to grow and attractive to butterflies. In mid- to late summer, this graceful selection has reddish purple, cone-shaped flowerheads on long, arching stems, giving a weeping appearance. Prune in spring to keep under control.

H: 10 ft (3 m), **S**: 6 ft (2 m)
❄❄❄ ◊ ☼



Cestrum parqui
An unusual shrub that is ideal for a warm, sunny wall. Its greenish yellow flowerheads, which are scented at night, appear from spring until frost. In cold areas, the plant may die to the ground, but will usually grow again from the root.

H: 10 ft (3 m), **S**: 6 ft (2 m)
❄❄ ◊ ☼

Clematis '*Alba Luxurians*'
One of the most rewarding clematis, this plant bears masses of small green-tipped white flowers with black anthers. Mature plants scramble up trellis to cover a wall or fence, but may overwhelm shrubs or small trees. In late winter, cut back to 8 in (20 cm).

H: 15 ft (5 m), **S**: 5 ft (1.5 m)
❄❄❄ ◊ ☼

Clematis cirrhosa
Both evergreen and winter-flowering, this scrambling climber needs a sunny position, but is a quick-growing, easy plant. The shiny leaves make a good foil to the creamy, bell-shaped flowers, which can be speckled with red inside; fluffy seedheads follow.

H: 20 ft (6 m), **S**: 10 ft (3 m)
❄❄ ◑ ◊ ☼

Clematis '*Perle d'Azur*'
This plant makes an excellent addition to a small garden. It produces blue blooms in succession from midsummer to fall. The flowers are tinged violet as they open, but fade to blue as they age. Prune stems to 8 in (20 cm) in late winter.

H: 10 ft (3 m), **S**: 5 ft (1.5 m)
❄❄❄ ◊ ☼













Cornus kousa *var.* chinensis
This must rank as one of the best garden plants. White or pink spring flowers with showy bracts are followed by red, strawberry-like fruits. Mature plants become more treelike and the flower displays ever more spectacular.

H: 22 ft (7 m), **S**: 15 ft (5 m)
❄❄❄ ◑ ☼

Cotinus coggygria '*Royal Purple*'
For lovers of colored foliage, this large shrub is a good choice. The rich red-purple leaves offset pale-colored flowers at the back of a border. In summer, wispy flowerheads may be produced; in fall, leaves gradually turn scarlet before falling.

H: 15 ft (5 m), **S**: 12 ft (4 m)
❄❄❄ ◑ ◊ ☼ ◑

Cynara cardunculus
The cardoon makes a fine plant even in small gardens, with its architectural form, silver-green foliage, and purple, thistlelike flowers, which attract bees. Place at the back of a border or use as a feature plant for a sunny corner. It dies to the ground in winter.

H: 6 ft (2 m), **S**: 4 ft (1.2 m)
❄❄ ◊ ☼

Tall plants for sun (Ja–Tr)

Jasminum nudiflorum
Of all winter-flowering plants, this jasmine, usually grown as a climber, is perhaps the most reliable. Small, bright yellow flowers appear all winter on leafless, dark green stems. Hard frost will claim some blooms, but more are produced in mild spells.

H: 12 ft (4 m), **S**: 12 ft (4 m)
❄❄❄ 💧 ◑ ☼ ☼



Juniperus communis '*Hibernica*'
This conifer brings contrast, structure, and backbone to the small garden. With blue-green, prickly needles and a dense-growing, compact habit, it eventually forms a column several yards high, standing out from rounded and horizontal growth.

H: 15 ft (5 m), **S**: 24 in (60 cm)
❄❄❄ 💧 ◑ ☼ ☼



Mahonia *x* media '*Buckland*'
A useful shrub with glossy evergreen foliage, architectural form, and sweetly scented, bright yellow flowers held in spikes during the darkest winter months. The leaves are spiny; weeding beneath these plants is best done wearing gloves.

H: 12 ft (4 m), **S**: 10 ft (3 m)
❄❄❄ 💧 ◑ ☼ ☼





Malus '*John Downie*'
This compact crabapple is perhaps the best of its kind for a profusion of ornamental fruit in late summer. Yellow and orange in color, and large, the apples stand out from the deciduous foliage. In spring, pure white blossoms open from pink buds.

H: 30 ft (10 m), **S**: 20 ft (6 m)
❄❄❄ ◑ ☼ ☼



Olea europaea
The olive has become viable for temperate gardens, thanks to milder winters. It needs a sheltered site and as much sun as possible. It then makes a noble specimen with evergreen, silver-green foliage and a gray trunk. Small white flowers appear in summer.

H: 20 ft (6 m), **S**: 15 ft (5 m)
❄❄ 💧 ☼



Photinia *x* fraseri '*Red Robin*'
Evergreen photinia is at its glorious best in spring when the new bright copper-red growth appears; the large, smooth leaves retain a reddish tinge as they mature. It can be used as a hedge, since it responds well to pruning, and is quite compact.

H: 10 ft (3 m), **S**: 10 ft (3 m)
❄❄ ◑ ☼ ☼

Prunus *x* subhirtella '*Autumnalis Rosea*'
This tree suits those who like to enjoy the garden all year. Delicate, starry, pale pink flowers are produced between fall and spring. New spring growth is bronze-green, turning dark green as the leaves expand.

H: 25 ft (8 m), **S**: 20 ft (6 m)
❄❄❄ ◊ ◑ ☼



Robinia pseudoacacia '*Frisia*'
This deciduous tree's golden foliage provides dramatic contrast to other plants and illuminates dark urban gardens. Plants are usually grafted and have thorny, brittle stems; remove any suckers with green leaves that appear from the base.

H: 50 ft (15 m), **S**: 25 ft (8 m)
❄❄❄ ◑ ☼



Romneya coulteri
The tree poppy is a distinguished perennial that sends up tall yet slender, unbranched stems with silvery leaves that in mid- to late summer are topped by huge, scented, gold-centered flowers with delicate white petals.

H: 6 ft (2 m), **S**: 6 ft (2 m)
❄❄❄ ◊ ☼





Solanum crispum '*Glasnevin*'
This glamorous relative of the potato has scrambling stems, and makes a beautiful wall shrub. Small purple flowers with yellow centers appear in bunches all summer and associate well with clematis and roses. Plants respond well to light trimming in spring.

H: 12 ft (4 m), **S**: 6 ft (2 m)
❄❄ ◊ ☼



Sorbus cashmiriana
With its open growth habit, delicate foliage, and pink flowerheads in early summer, this tree is a good choice. In fall and early winter, the canopy is resplendent with clusters of shiny white fruits the size of small marbles that linger after the leaves have fallen.

H: 25 ft (8 m), **S**: 20 ft (6 m)
❄❄❄ ◊ ◑ ☼ ◑



Trachelospermum asiaticum
This evergreen climber is an excellent plant for the smaller garden; it does best in a sheltered spot. Small glossy leaves form dense cover up walls or over fences, and from early summer, clusters of starry, strongly scented cream flowers appear.

H: 12 ft (4 m), **S**: 10 ft (3 m)
❄❄ ◊ ◑ ☼ ◑

Tall plants for shade (Ac–St)

Acer palmatum *var.* dissectum *Dissectum Atropurpureum Group*
This is one of the most popular of small Japanese acers, with rich purple foliage. Slow-growing, it eventually forms a low, mounded shrub. The delicate leaves may be damaged by drying winds, so give it some shelter.

H: 6 ft (2 m), **S**: 10 ft (3 m)
❄❄❄ ◊ ◑ ☼



Camellia sasanqua
Most camellias bloom in spring, but those of *C. sasanqua* open in late fall. There are many cultivars, with scented single or semidouble flowers in white or pink. Train stems against a sheltered wall to protect the flowers from frost. Needs acidic soil.

H: 12 ft (4 m), **S**: 6 ft (2 m)
❄❄❄ ◊ ◑ ☼ ☼



Cercis canadensis '*Forest Pansy*'
One of the most desirable of all deciduous shrubs, this is grown for its heart-shaped, rich purple foliage and clusters of purple, pealike flowers in spring. In fall, the leaves develop orange tints before falling. Grow it in a sheltered position.

H: 10 ft (3 m), **S**: 10 ft (3 m)
❄❄❄ ◑ ☼ ☼





Daphne bholua '*Jacqueline Postill*'
It is worth spending time finding a good spot for this evergreen daphne. In winter, it bears a profusion of waxy pink flowers with an intoxicating perfume that carries on the wind. It is best planted in a sheltered spot.

H: 10 ft (3 m), **S**: 5 ft (1.5 m)
❄❄ ◊ ◑ ☼



Dicksonia antarctica
This tree fern is one of the most recognizable of exotic plants. Its bright green fronds unfurl from tight croziers that appear from the tip of the slow-growing trunk. These plants need shelter, moisture, and protection in cold winters.

H: 20 ft (6 m), **S**: 13 ft (4 m)
❄❄ ◑ ☼



Fatsia japonica
Few hardy plants provide more impact than fatsia, with its large, leathery, hand-shaped leaves. In fall, heads of white flowers are followed by drooping bunches of shiny, black berries. It develops an elegant, upright habit with age.

H: 10 ft (3 m), **S**: 6 ft (2 m)
❄❄ ◊ ◑ ☼ ☼

Hydrangea quercifolia
Most hydrangeas are grown for their showy flowerheads, but this species is better known for its oaklike foliage, which develops dramatic autumnal colors before falling. Creamy white, conical flowerheads are long-lasting. It remains a compact shrub.

H: 5 ft (1.5 m), **S**: 3 ft (1 m)
❄❄❄ ◑ ☼

Ilex aquifolium '*Silver Queen*'
This slow-growing holly is a reliable performer. It eventually forms a large, cone-shaped shrub with prickly evergreen leaves edged with silver. An undemanding shrub for a dark corner or shaded border, it is a male plant and will not produce berries.

H: 40 ft (12 m), **S**: 10 ft (3 m) or more
❄❄❄ ◊ ◑ ☼ ◑

Lonicera periclymenum '*Graham Thomas*'
This is one of the best honeysuckles. It is shade-tolerant, free-flowering, and well scented, especially in the evening. Creamy yellow, tubular flowers appear in early summer and throughout the season.

H: 12 ft (4 m), **S**: 10 ft (3 m)
❄❄❄ ◊ ◑ ☼ ◑













Phyllostachys
Beloved of garden designers, this bamboo is an excellent, well-behaved, clump-forming plant. *P. nigra* has rich ebony stems that contrast well with the bright green foliage. Remove lower branchlets and older stems to show off the color of the stems.

H: 22 ft (7 m), **S**: 15 ft (5 m)
❄❄❄ ◊ ◑ ☼ ◑

Sambucus racemosa '*Plumosa Aurea*'
In spring and summer, this deciduous shrub is furnished with delicate, gold feathery foliage; the young shoots are tinged bronze. It is best if the stems are cut down annually to about 24 in (60 cm) in early spring.

H: 10 ft (3 m), **S**: 6 ft (2 m)
❄❄❄ ◊ ◑ ☼ ◑

Stewartia monadelpha
Stewartias are deciduous trees, often developing mottled trunks and impressive autumnal tints before leaf fall. This species is one of the more widely available, producing white summer flowers like those of a small camellia. Grow it in a sheltered spot.

H: 70 ft (20 m), **S**: 15 ft (5 m)
❄❄❄ ◑ ☼ ◑

Medium-sized plants for sun (Ac–Co)

Acanthus mollis
With mounds of glossy architectural foliage and handsome prickly spires of purple flowers, this perennial will add a touch of drama to any garden. The large, rich green leaves that emerge in early spring may be damaged by frost.

H: 6 ft (2 m), **S**: 6 ft (2 m)
❄❄ ☼ ☀

Allium hollandicum '*Purple Sensation*'
This bulb flowers after the spring bulbs but before summer flowers get going. Rounded, metallic purple flowerheads are carried on tall, slender stems that punctuate lower plantings. Plant in drifts in spring.

H: 4 ft (1.2 m), **S**: 8 in (20 cm)
❄❄❄ ☼

Angelica archangelica
This herbaceous plant flowers, sets seed, and dies in two years. In its first year, it produces unremarkable clumps of large, divided leaves, but in the second year, it is transformed. A thick stem is topped by soccer-ball-sized heads of bright green flowers.

H: 8 ft (2.5 m), **S**: 4 ft (1.2 m)
❄❄❄ ◑ ☼ ☀








Aster turbinellus
Reaching its best in early fall, this aster has mauve daisy flowers held aloft on slender stems. The yellow-centered blooms are produced in profusion, creating a dainty effect. The stems may need extra support; position any canes or twigs early.

H: 3 ft (1 m), **S**: 3 ft (1 m)
❄❄❄ ◑ ☼

Berberis thunbergii *f.* atropurpurea '*Dart's Red Lady*'
Berberis are tough and easy to grow, but some make first-rate flowering or foliage plants. This deciduous cultivar with viciously spiny stems is grown for its richly colored red leaves, making a good foil for other garden plants.

H: 4 ft (1.2 m), **S**: 6 ft (2 m)
❄❄❄ ◑ ☼ ☀

Bupleurum fruticosum
This is a fine shrub for a sunny spot, forming a mound of silver-green evergreen foliage, and producing delicate heads of tiny, bright yellow flowers all summer. It thrives in dry, chalky soil and also in the open in mild coastal areas.

H: 6 ft (2 m), **S**: 6 ft (2 m)
❄❄ ☼

Buxus sempervirens
Boxwood has a long history in cultivation, thanks to its evergreen nature and responsiveness to clipping. Use as topiary, a low hedge, or shape it to add formality. 'Marginata' (pictured) has yellow-edged leaves. Dislikes waterlogged soil.

H: 10–12 ft (3–4 m) if unclipped, **S**: 6 ft (2 m) ❄❄❄ 💧 ◑ ☼ ☀

Canna '*Striata*'
Thanks to their exotic flowers and bold foliage, cannas make great plants for a sunny garden. 'Striata' has yellow-striped green leaves and orange flowers in summer. Lift the rhizomes and keep frost-free, or protect with a thick mulch in winter.

H: 6 ft (2 m), **S**: 3 ft (1 m)
❄ ◑ ☼

Chimonanthus praecox
In summer, this deciduous shrub is unremarkable; in winter, small rounded buds swell and open to waxy, creamy yellow, bell-shaped flowers with a purple center. Their spicy perfume gives the plant its common name of wintersweet.

H: 10 ft (3 m), **S**: 6 ft (2 m)
❄❄❄ 💧 ☼













Choisya ternata *Sundance*
This neat shrub is popular due to its golden evergreen foliage, which is lightly aromatic, as are the sprays of white flowers. It is best grown in some shade, where it becomes lime green and has an illuminating presence. Dislikes waterlogged soil.

H: 6 ft (2 m), **S**: 5 ft (1.5 m)
❄❄ 💧 ☼ ☀

Cistus *x* hybridus
This easy, evergreen shrub is a sight to behold in early summer. For two to three weeks, it is smothered in masses of single, white flowers with a yellow eye. Cistus are not long-lived, but they will endure drought for a while.

H: 4 ft (1.2 m), **S**: 5 ft (1.5 m)
❄❄ 💧 ☼

Correa '*Dusky Bells*'
This charming, winter-flowering plant is worth growing in a sheltered, sunny position. Low and shrubby, it has small, evergreen leaves and bears pinkish-red, bell-shaped flowers with protruding anthers in mild spells during winter. It needs shelter.

H: 3 ft (1 m), **S**: 24 in (60 cm)
❄❄ 💧 ◑ ☼

Medium-sized plants for sun (Cr–Hi)

Crocosmia *x* crocosmiiflora '*Venus*'
The common montbretia has strappy leaves topped by sprays of orange flowers in late summer, but there are many rather more desirable selections. *C.* x *crocosmiiflora* 'Venus', with gold and red flowers, is a good example.

H: 20 in (50 cm), **S**: 24 in (60 cm)
❄❄ 💧 ◑ ☼ ◑

Dahlia '*Bishop of Llandaff*'
This popular old cultivar produces velvety, red, single flowers above purple foliage. It is compact, making it good for the smaller yard, and a fine companion for other late-flowering perennials. Lift the plant in winter and keep the tubers frost-free.

H: 4 ft (1.2 m), **S**: 24 in (60 cm)
❄ ◑ ☼

Deutzia *x* rosea '*Campanulata*'
This compact, deciduous shrub makes a good undemanding plant for the smaller garden. It has upright, twiggy growth and hairy leaves. The blooms, which are bell-shaped and white with a pink tinge, remain beautiful for several weeks.

H: 4 ft (1.2 m), **S**: 4 ft (1.2 m)
❄❄❄ 💧 ◑ ☼ ◑













Dierama pulcherrimum
The wand flower or angel's fishing rod is aptly named. In summer, long, arching sprays of large, bell-shaped flowers appear from tufts of tough, strappy, evergreen leaves. Flowers are usually pink but sometimes white or even dark purple.

H: 5 ft (1.5 m), **S**: 24 in (60 cm)
❄❄ ◑ ☼

Echinacea purpurea
The coneflower is a most appealing herbaceous plant, producing pinky-purple daisylike flowers with a large, dark central cone, tinged orange. The flowers are held on sturdy stems, although sideshoots carry later blooms that appear well into fall.

H: 4 ft (1.2 m), **S**: 24 in (60 cm)
❄❄❄ 💧 ☼

Euphorbia characias
This evergreen perennial is a superb early summer-flowering plant, with rounded heads of lime green bracts surrounding insignificant flowers. The sea green, lance-shaped leaves are carried on fleshy stems that bleed a milky, toxic sap if cut.

H: 5 ft (1.5 m), **S**: 3 ft (1 m)
❄❄ 💧 ◑ ☼

Euphorbia *x* martinii
This spurge is a good choice, being of compact but upright growth and particularly effective in flower. The green blooms have red centers and appear in spring on tall, rounded, airy heads, carried on purple stems with dark evergreen leaves.

H: 24 in (60 cm), **S**: 24 in (60 cm)
❄❄❄ ◊ ☼

Grevillea '*Canberra Gem*'
For much of the year, this unusual evergreen shrub is quietly attractive, clad in narrow, almost needlelike, bright green leaves. In summer, it is transformed with exotic-looking, pink-red flowers dangling here and there. It needs acidic soil.

H: 5 ft (1.5 m), **S**: 5 ft (1.5 m)
❄❄ ◊ ☼

Hebe '*Midsummer Beauty*'
The length of its floral display makes this evergreen hebe worthy of space in the garden. In midsummer, long spikes of violet and white flowers are produced. They have a delicate fragrance and continue into fall, even winter, if the weather is mild.

H: 6 ft (2 m), **S**: 6 ft (2 m)
❄❄ ◊ ◑ ☼ ◒













Helenium '*Moerheim Beauty*'
This late-flowering border perennial is deservedly popular. From mid- to late summer to early fall, it produces shuttlecock-shaped, daisylike flowers in rich marmalade shades on sturdy, upright stems. Deadheading ensures a later flush of blooms.

H: 4½ ft (1.4 m), **S**: 3 ft (1 m)
❄❄❄ ◊ ◑ ☼

Hemerocallis '*Corky*'
A clump-forming perennial with narrow, strappy foliage. Slender stems appear in summer, carrying clusters of orange-yellow, funnel-shaped flowers, each displaying a red tinge to the outside. The blooms last just a day but are soon followed by others.

H: 24 in (60 cm), **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼ ◒

Hibiscus syriacus '*Oiseau Bleu*'
Few shrubs better this hibiscus in full bloom. Just as many other plants are fading, it produces a profusion of 3-in- (8-cm-) wide, open bell-shaped flowers of rich blue—a rare color so late in the season. The flowers last until early fall.

H: 8 ft (2.5 m), **S**: 5 ft (1.5 m)
❄❄❄ ◊ ☼

Medium-sized plants for sun (In–Ph)

Inula hookeri
This clump-forming perennial should be more widely grown. It produces beautiful yellow flowers with slender petals that appear from midsummer at the tips of soft stems bearing hairy oval leaves. In late fall, the shoots can be cut to the ground.

H: 24 in (60 cm), **S**: 24 in (60 cm)
❄❄❄ ◑ ☼



Iris laevigata
This plant is perfect for moist areas, growing well even in standing water. The sword-shaped foliage provides a contrast to other shrubby growth. In early to midsummer, flowering stems bear a succession of beautiful blooms, usually lavender-blue in color.

H: 20 in (50 cm), **S**: 12 in (30 cm)
❄❄❄ ◑ ● ☼ ◑



Iris sibirica '*Perry's Blue*'
Siberian irises are good for ground that does not dry out. In spring, slender, strappy foliage erupts from clumps, followed by tall, branched, flowering stems. These bear dainty sky blue flowers with white markings, 2½ in (6 cm) across, over several weeks.

H: 3 ft (1 m), **S**: 20 in (50 cm)
❄❄❄ ◑ ● ☼ ◑





Lavandula stoechas
With its aromatic foliage and long-lasting flowers, French lavender lends a Mediterranean feel to sunny gardens. The flowerheads have distinctive purple "ears," or bracts, held on stems above the narrow, grayish-green leaves. Grow in a sheltered spot.

H: 24 in (60 cm), **S**: 24 in (60 cm)



Lilium regale
This is an easy lily to grow. Fleshy stems furnished with narrow leaves appear in spring and grow rapidly. Large buds swell and burst to reveal silver-white, trumpet-shaped flowers with protruding stamens and a wonderful scent.

H: 5 ft (1.5 m), **S**: 12 in (30 cm)
❄❄❄ ◊ ☼ ◑



Lobelia tupa
In spring, this exotic-looking plant produces fleshy, red-flushed shoots with large, rather downy leaves. In late summer, heads of red, tubular flowers open over several weeks, and last well into fall. Cut stems to the ground after the first frost.

H: 6 ft (2 m), **S**: 3 ft (1 m)
❄❄ ◊ ◑ ☼

Melianthus major
A remarkable foliage plant, with dramatic, blue-silver, deeply cut leaves that look superb in a white border or with contrasting purple foliage. Usually it is cut to the ground by frost, and should be covered with a thick mulch to protect the roots.

H: 6 ft (2 m), **S**: 3 ft (1 m)
❄❄ ◊ ◑ ☼

Miscanthus sinensis '*Zebrinus*'
With its tall stems and strappy foliage, this ornamental grass is a favorite. The leaf blades are marked with broad yellow stripes, giving the plant a remarkable appearance, especially when grown in full sun, which helps intensify the markings.

H: 6 ft (2 m), **S**: 3 ft (1 m)
❄❄❄ ◑ ☼ ◑

Nandina domestica
A most useful shrub, this plant checks all the boxes. It has a delicate yet architectural form with large, divided leaves that develop attractive autumnal tints. In early summer, sprays of white flowers appear, followed by clusters of orange berries that persist into winter.

H: 6 ft (2 m), **S**: 6 ft (2 m)
❄❄❄ ◊ ☼ ◑













Pennisetum setaceum '*Rubrum*'
This delightful grass is a tender perennial, ideal for a container in a sunny spot during summer. Best treated as an annual, it will produce purple fluffy flowerheads (known as "cats' tails") held on arching stems, above rich red foliage.

H: 3 ft (1 m), **S**: 24 in (60 cm)
❀ ◑ ◊ ☼

Perovskia '*Blue Spire*'
This delicate-looking, shrubby plant is a good choice for a sunny, dry position. It forms an upright bush with strongly aromatic, silver-green foliage. From late summer until fall, clouds of violet-blue flowers are produced.

H: 4 ft (1.2 m), **S**: 3 ft (1 m)
❄❄❄ ◊ ☼

Phlomis russeliana
A dependable, useful perennial with large, soft, heart-shaped leaves that cover the ground well, even in winter. In early summer, attractive stout stems of soft yellow flowers appear. After flowering, these stems provide structure into fall and winter.

H: 3 ft (1 m), **S**: 4 ft (1.2 m)
❄❄❄ ◑ ◊ ☼ ◑

Medium-sized plants for sun (Ph–We)

Phormium '*Yellow Wave*'
This tried-and-tested phormium is graceful and compact. Its broad, evergreen, strappy foliage is lavishly marked with yellow, set against green, each blade arching gracefully to give established clumps an elegant appearance.

H: 4 ft (1.2 m), **S**: 3 ft (1 m)
❄❄ 💧 ◑ ☼ ◑

Pinus mugo '*Ophir*'
This compact, slow-growing pine is ideal for the smaller garden, growing well even in a container. Its short branching stems are covered in dense bristles and it will form a large shrub. However, it is most attractive in winter, when its needles turn bright gold.

H: 5 ft (1.5 m), **S**: 5 ft (1.5 m)
❄❄❄ 💧 ☼

Pittosporum tobira
With its shiny, evergreen leaves and heads of cream-colored, sweetly scented summer flowers, this plant should be seen more often. It grows throughout the Mediterranean, so is a good choice for those who like to be reminded of warmer climes.

H: 6 ft (2 m), **S**: 6 ft (2 m)
❄❄ 💧 ☼













Rosa *x* odorata '*Mutabilis*'
A most beautiful rose that flowers from late spring until late fall. Clusters of dainty, single flowers open a warm orange-yellow and turn rich pink with age. The young stems and leaves of this compact, but open, bush are tinged purple.

H: 3 ft (1 m), **S**: 3 ft (1 m)
❄❄ 💧 ☼

Rosa xanthina '*Canary Bird*'
This rose is one of the earliest to bloom—in late spring. It produces a profusion of single, sunshine yellow flowers, which have a light perfume, and has attractive apple green foliage. A second reduced display appears in fall.

H: 6 ft (2 m), **S**: 6 ft (2 m)
❄❄❄ 💧 ☼

Rosmarinus officinalis
This dense evergreen has strongly aromatic foliage and attractive blue flowers in spring and sometimes fall. It will grow well in pots, is drought-tolerant, and responds well to trimming. It is a useful herb for cooking.

H: 5 ft (1.5 m), **S**: 5 ft (1.5 m)
❄❄ 💧 ☼

Salvia officinalis '*Purpurascens*'
Purple sage is a useful plant for the smaller garden: it is easy, quick-growing, and has aromatic, oval, soft, purple leaves. The plant forms ground-covering mounds, and in summer sends up flowering stems with small purple blooms.

H: 3 ft (1 m), **S**: 3 ft (1 m)
❄❄ ☼

Salvia *x* sylvestris '*Mainacht*'
Many salvias are first-rate plants for their summer flowers; this compact selection is useful in the smaller plot. Its early summer flowers are of an intense purplish-blue that is unusual for the time of year. They are carried in profusion in stiff upright spikes.

H: 3 ft (1 m), **S**: 20 in (50 cm)
❄❄ ☼

Stipa gigantea
The perennial giant oat, although large, is manageable in almost any garden. It forms a low hummock of long, narrow leaves, and in summer, produces tall stems bearing transparent golden flowerheads that shimmer in the breeze.

H: 6 ft (2 m), **S**: 3 ft (1 m)
❄❄❄ ☼ ◑













Trachycarpus wagnerianus
This is the perfect hardy palm for smaller yards, as it is slow-growing and compact. The plant forms a trunk gradually and is furnished with fan-shaped, dark, evergreen, deeply pleated leaves that give it a most refined appearance.

H: 6 ft (2 m) after 10 years, **S**: 6 ft (2 m)
❄❄❄ ☼ ◑ ☼ ◐

Verbena bonariensis
This "must-have" perennial is a useful plant even in small gardens because, although tall, it has a transparent quality, allowing views of plantings behind it. It is long-flowering, with heads of purple blooms appearing in summer and lasting into fall.

H: 6 ft (2 m), **S**: 24 in (60 cm)
❄❄ ☼

Weigela '*Eva Rathke*'
These shrubs are grown for their spring and early summer blossoms. This compact selection forms a dense shrub. Dark red flower buds appear in profusion in late spring and open to crimson, funnel-shaped flowers. Remove oldest stems after flowering.

H: 5 ft (1.5 m), **S**: 5 ft (1.5 m)
❄❄❄ ☼ ◐

Medium-sized plants for shade (Ac–De)

Acer shirasawanum '*Aureum*'
This slow-growing, compact plant is striking, especially in late spring and early summer when its foliage is at its best. As the golden leaves expand, they resemble little Chinese fans, seen to best effect in shade where they stand out from other plantings.

H: 5 ft (1.5 m) after 10 years, **S**: 3 ft (1 m)
❄❄❄ ◊ ◑ ☼

Anemanthele lessoniana
This grass is better known as *Stipa arundinacea*. It makes a neat clump of fairly broad, evergreen foliage, the leaves arching attractively. In late summer, tiny flowers are produced. In fall, the clump develops russet tints, adding to its desirability.

H: 4 ft (1.2 m), **S**: 4 ft (1.2 m)
❄❄ ◊ ☼ ◑

Anemone *x* hybrida '*Honorine Jobert*'
There are few perennials to match this noble plant in late summer. Vigorous clumps of bold, divided foliage build up steam through the summer until flowering stems appear, topped by sprays of single, white flowers.

H: 5 ft (1.5 m), **S**: 24 in (60 cm)
❄❄❄ ◑ ◑








Aquilegia *McKana Group*
A cottage-garden favorite, this perennial is a good choice for its spring flowers in a wide range of different colors. The clumps of foliage develop in spring and are soon topped by distinctive flowers lasting for several weeks.

H: 3 ft (1 m), **S**: 20 in (50 cm)
❄❄❄ ◊ ☼ ◑

Aruncus dioicus
This large but easy-to-grow perennial is suited to moist sites. In spring, shoots soon form hummocks of leafy stems. By midsummer, plumes of tiny creamy white flowers appear. They are held in handsome flowerheads and last for several weeks.

H: 6 ft (2 m), **S**: 4 ft (1.2 m)
❄❄❄ ◑ ● ☼ ◑

Astilboides tabularis
A plant of great beauty, this species' main feature is its large, parasol-like leaves, each roughly circular, with the leaf stem attached to the center. Soft green and delicate in early summer, they darken as the season progresses. White flowers appear in late summer.

H: 5 ft (1.5 m), **S**: 3 ft (1 m)
❄❄❄ ◑ ● ◑

Aucuba japonica
This evergreen deserves recognition as one of the best shrubs for year-round appeal. It will also withstand mistreatment. Its large oval leaves are spangled with golden spots. In spring, heads of red-purple flowers appear and develop into crimson berries.

H: 8 ft (2.5 m), **S**: 8 ft (2.5 m)
❄❄❄ ◊ ◑ ● ◑



Berberis darwinii
This spiny evergreen is one of the most spectacular spring-flowering shrubs and deserves a spot at the back of a border. The glossy foliage is an attractive foil to the clusters of bright orange flowers that cover the plant, followed later by blue berries.

H: 6 ft (2 m) after 10 years, **S**: 6 ft (2 m)
❄❄❄ ◊ ◑ ◑



Camellia japonica '*Bob's Tinsie*'
This plant is a favorite, thanks to its unusual flowers and neat, compact habit. The glossy, oval, evergreen foliage is a good foil to the small, cup-shaped, red flowers that appear in abundance throughout spring.

H: 5 ft (1.5 m), **S**: 3 ft (1 m)
❄❄❄ ◊ ◑ ◑





Cornus sanguinea '*Winter Beauty*'
This shrub is grown for the color of its twigs. In summer, it is forgettable, but once the leaves turn butter yellow in fall, the show begins. The stems are bright orange-yellow, the younger shoots tinged red, making the plant look like a glowing flame.

H: 6 ft (2 m), **S**: 6 ft (2 m)
❄❄❄ ◑ ☼ ◑



Cotoneaster horizontalis
This shrub has much to recommend it. In spring, the soft green foliage is the attraction, followed by pink-white flowers in summer. In fall, the leaves turn crimson before they drop; in winter, the stems are often peppered with red berries.

H: 6 ft (2 m), **S**: 6 ft (2 m)
❄❄❄ ◊ ◑ ☼ ◑



Desfontainia spinosa
At first glance, this plant resembles a compact holly with its small, dark, spine-edged leaves. In summer, it has a trick up its sleeve: long, tubular, pendent, red and yellow flowers appear, and are of great beauty, especially against the dark foliage.

H: 3 ft (1 m), **S**: 24 in (60 cm)
❄❄ ◑ ◑

Medium-sized plants for shade (Di–Le)

Dicentra spectabilis
The bleeding heart is a popular plant for light shade. Fleshy shoots emerge as winter ends and are easily damaged by late frosts. The soft foliage, which dies down in midsummer, is topped by arching sprays of pink and white flowers that last for several weeks.

H: 3 ft (1 m), **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼

Digitalis purpurea
The foxglove is easy to grow, thrives in shade, and seeds freely. It is usually a biennial, which means it lives for two years, building up a rosette of large oval leaves in the first, and producing its tall flower spike in the second. The flowers are usually purple or white.

H: 6 ft (2 m), **S**: 24 in (60 cm)
❄❄❄ ◑ ☼ ☼

Geranium *x* oxonianum '*Claridge Druce*'
This herbaceous plant is one of the toughest, and ideal for dry shade. It develops a mound of foliage that is often semievergreen, above which appear bright pink flowers from spring until late fall.

H: 4 ft (1.2 m), **S**: 3 ft (1 m)
❄❄❄ ◊ ◑ ● ☼ ☼













Hedychium densiflorum
This hardy ginger makes a fine late-flowering perennial. In summer, it develops vigorous, fleshy shoots that grow quickly and display lush foliage. At the tips of each shoot appear spikes of scented, orange flowers that are produced well into fall.

H: 4 ft (1.2 m), **S**: 6 ft (2 m)
❄❄ ◊ ◑ ☼ ☼

Helleborus argutifolius
This evergreen perennial is a useful plant, growing well in shade and filling gaps with its handsome serrated foliage, held on rather shrubby stems. In winter, bright green, open flowers appear. After flowering, stems wither and yellow and should be cut out.

H: 3 ft (1 m), **S**: 3 ft (1 m)
❄❄ ◊ ◑ ☼ ☼

Hosta '*Jade Cascade*'
This huge, sturdy yet elegant hosta is well named. The long, pointed, rich green leaves, up to 12 in (30 cm) long, are strongly veined and held in a distinctive, downward-facing way on tall leaf stems. In early summer, tall spires of lilac blooms appear.

H: 4 ft (1.2 m), **S**: 3½ ft (1.1 m)
❄❄❄ ◑ ☼

Hosta sieboldiana
This large hosta has fine foliage. The leaves, which emerge from blue, toothlike shoots in spring, are blue-gray at first, developing a green tinge as they age. Mature clumps make large mounds of puckered leaves 12 in (30 cm) long and the same across.

H: 3 ft (1 m), **S**: 3 ft (1 m)
❄❄❄ ◑ ☼

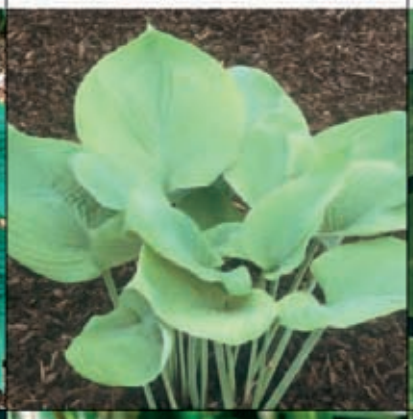
Hosta '*Sum and Substance*'
A spectacular hosta cultivar that is one of the largest and easiest to grow of all, with huge golden-green leaves, especially bright as they first emerge in spring. In summer, tall spikes of lavender flowers appear. This hosta is also relatively slug-resistant.

H: 30 in (75 cm), **S**: 4 ft (1.2 m)
❄❄❄ ◑ ☼

Hydrangea macrophylla '*Lanarth White*'
This hydrangea forms a rounded dome of growth. The flattened heads are composed of tiny blue or pink fertile flowers surrounded by pure white florets, and appear in late summer. The flowers show up best in shade.

H: 3 ft (1 m), **S**: 3 ft (1 m)
❄❄❄ ◊ ◑ ☼













Ilex crenata *var.* latifolia
This holly looks rather like boxwood, but it is quicker-growing. It responds well to trimming and can be kept as a low hedge. Other selections include *I. crenata* 'Golden Gem', which has glowing yellow foliage and makes a superb plant for shade.

H: up to 5 ft (1.5 m), **S**: 5 ft (1.5 m)
❄❄❄ ◊ ◑ ☼ ☼

Iris foetidissima
This perennial is great for shade, even under trees and shrubs. The lance-shaped foliage remains in good condition in winter, and in spring, purple flowers appear. The orange seeds, which remain showy all winter, are the main talking point.

H: 3 ft (1 m), **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼

Leucothoe fontanesiana '*Rainbow*'
A clump-forming evergreen shrub with an attractive, arching, fountain-shaped habit. The leaves are splashed and flecked with cream, pink, and orange. In summer, white, bell-shaped flowers hang from the stems.

H: 5 ft (1.5 m), **S**: 4 ft (1.2 m)
❄❄❄ ◑ ☼

Medium-sized plants for shade (Le–Vi)

Leycesteria formosa
An excellent shrub for a range of situations, including dry shade. In summer, clusters of pinky-purple flowers hang from arching stems amid lush oval leaves. By fall, purple berries develop. The green stems are attractive in winter.

H: 5 ft (1.5 m), **S**: 4 ft (1.2 m)
❄❄❄ ◊ ◑ ☼ ☼

Ligularia dentata '*Desdemona*'
This leafy perennial is a dramatic choice for moist sites. Clumps of large, rounded leaves flushed with purple are held on long stems, which appear from the ground in spring. These are followed by tall stems with orange-yellow, daisylike flowers.

H: 4 ft (1.2 m), **S**: 24 in (60 cm)
❄❄❄ ◑ ● ☼

Osmunda regalis
A large, deciduous fern, ideal for moist areas. In spring, croziers unwind from the ground and fresh, bright green fronds unfurl. Clumps provide an architectural element in summer; in fall, they turn bright yellow.

H: 4 ft (1.2 m), **S**: 3 ft (1 m)
❄❄❄ ◑ ● ☼













Pieris '*Forest Flame*'
This evergreen shrub is grown for its dramatic, bright red shoots and sprays of white, bell-shaped flowers. The flowers appear in early spring before the scarlet shoots. As the leaves mature, they fade to pink before turning green. It needs acidic soil.

H: 8 ft (2.5 m), **S**: 6 ft (2 m)
❄❄❄ ◑ ☼

Primula florindae
The largest and most spectacular of primulas, this perennial resembles a giant cowslip. Clumps of broad, soft green leaves 12 in (30 cm) long develop in spring, followed by tall flower stems that carry scented, bell-shaped flowers in yellow or orange.

H: 4 ft (1.2 m), **S**: 24 in (60 cm)
❄❄❄ ◑ ☼

Rhododendron '*Olive*'
This evergreen rhododendron needs a sheltered position and acidic soil to do well. The small, green, oval leaves serve as a good foil to the clusters of bright mauve-pink, funnel-shaped flowers up to 1½ in (4 cm) across. These are produced in late winter.

H: 5 ft (1.5 m), **S**: 3 ft (1 m)
❄❄❄ ◑ ☼

Rhododendron '*Persil*'
This plant is a wonderful sight in late spring. Heads of large, scented, white flowers with a yellow flash in the center appear at the same time as the soft, hairy leaves. The flowers last for several weeks, and show up well in shade. The plant needs acidic soil.

H: up to 6 ft (2 m), **S**: 6 ft (2 m)
❄❄❄ ◑ ☼ ◑

Ribes sanguineum '*Brocklebankii*'
This compact flowering currant is most attractive in spring, the pink flowers appearing at the same time as the yellow leaves—to spectacular effect. This plant shows up well in shade and grows better out of sun because the leaves can scorch.

H: 5 ft (1.5 m), **S**: 3 ft (1 m)
❄❄❄ ◊ ◑

Sarcococca hookeriana *var.* digyna
Evergreen, compact, and winter flowering, this shade-loving plant is ideal for small gardens. The narrow leaves are shiny and the plant forms a dense, rounded mound. In winter, small, white tassels appear: these have a delicious, spicy scent.

H: 3 ft (1 m), **S**: 3 ft (1 m)
❄❄❄ ◊ ◑ ◑








Skimmia *x* confusa '*Kew Green*'
With its glossy, pointed leaves, this skimmia cultivar is one of the most reliable. The large, conical, greenish-cream flowerheads, produced in early spring, have a delicious scent. This is a male plant; for berries, a female or hermaphrodite plant is required.

H: 3 ft (1 m), **S**: 5 ft (1.5 m)
❄❄❄ ◑ ◑

Viburnum davidii
This evergreen shrub, which forms a low mound, is a plant for all seasons. The oval leaves are attractively pleated and rich green. In summer, large heads of small, white flowers appear. Bright blue berries follow, provided male and female plants are grown.

H: 3 ft (1 m), **S**: 6 ft (2 m)
❄❄ ◊ ◑ ◑

Viburnum tinus '*Eve Price*'
A compact and free-flowering evergreen plant that makes an ideal backdrop at the back of a border. It forms dense cover and has small, green, oval leaves. Heads of pink-tinged flowers are displayed through winter and spring.

H: 6 ft (2 m), **S**: 6 ft (2 m)
❄❄❄ ◊ ◑ ☼ ◑

Short plants for sun (Al–Di)

Allium schoenoprasum
Chives are not only useful in an herb garden—they are also an easy-to-grow choice for a flower garden and ideal as border edging. The narrow, blue-green leaves are especially attractive when topped by pinkish-mauve flowers that last several weeks.

H: 12 in (30 cm), **S**: 8 in (20 cm)
❄❄❄ ◊ ☼

Artemisia alba '*Canescens*'
This useful front-of-border perennial, with its silver leaves, should be more widely grown. The lacy foliage is held on stems that tend to sprawl, covering the soil well. Cut plants to the ground in a cold winter, and new shoots will appear in spring.

H: 12 in (30 cm), **S**: 12 in (30 cm)
❄❄ ◊ ☼

Aster '*Coombe Fishacre*'
In early fall, few plants can compete with asters. This selection has a long flowering period and is well suited to smaller gardens. The blooms are daisylike, pink with a darker eye, and appear in a multitude, lasting until the first frost.

H: 24 in (60 cm), **S**: 24 in (60 cm)
❄❄❄ ◊ ☼













Astrantia major
These beautiful perennials are becoming popular, thanks to the range now available. Clumps of leaves appear in spring and are topped by dainty flowers held on tall stems. The showy white or pink bracts resemble petals and encircle the true flowers.

H: 18 in (45 cm), **S**: 12 in (30 cm)
❄❄❄ ◊ ☼ ◑

Bergenia purpurascens
This perennial has beautiful foliage and flowers. It is more compact and has a longer season of interest than most bergenias, so it is better suited to small gardens. The glossy foliage develops rich purple tints in winter; in spring, pinkish-purple flowers appear.

H: 12 in (30 cm), **S**: 24 in (60 cm)
❄❄❄ ◊ ☼ ◑

Calluna vulgaris '*Silver Knight*'
For silver foliage, few heathers create a better effect than this shrubby, evergreen plant. When mature, it produces a wonderful wispy silver cloud of dense, quite upright, but ground-covering, growth. Although easy to grow, it must have acidic soil.

H: 12 in (30 cm), **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼

Campanula glomerata
One of the simplest campanulas to grow, this low, spreading perennial makes a good summer ground cover, and self-seeds freely. From early summer until fall, heads of bell-shaped blue or white flowers appear on short stems.

H: 12 in (30 cm), **S**: 3 ft (1 m)
❄❄❄ ◊ ◑ ☼ ☼

Catananche caerulea
This sun-loving perennial is grown for its lavender-blue flowers, which look rather like pale cornflowers, produced in summer and fall. The blooms are held on a wiry stalk above clumps of silvery foliage. They combine well with other pale-colored plants.

H: 24 in (60 cm), **S**: 12 in (30 cm)
❄❄ ◊ ☼

Ceratostigma plumbaginoides
Easy to grow, this low shrub flowers when most other plants have finished. It spreads at the root and, under ideal conditions, forms a large clump. The rich blue flowers are held in clusters above the leaves, which turn red before falling.

H: 12 in (30 cm), **S**: 24 in (60 cm)
❄❄ ◊ ☼













Cerinthe major
Growing swiftly from seed, this annual develops into a low bush, covered in blue-silver leaves. Long-lasting, purple, bell-shaped flowers appear in late spring, giving an attractive, almost iridescent appearance. It self-seeds freely.

H: 18 in (45 cm), **S**: 12 in (30 cm)
❄❄❄ ◊ ☼

Convolvulus cneorum
This evergreen, low-growing shrub is grown for both its soft, bright silver foliage and the multitude of white, cup-shaped flowers that appear in summer. Each flower lasts little more than a day, but the bush is covered in blooms for weeks.

H: 20 in (50 cm), **S**: 3 ft (1 m)
❄❄ ◊ ☼

Diascia barberae '*Blackthorn Apricot*'
Often grown as an annual, this plant is perennial in the right position. Although cut to the ground in winter, new stems appear in spring to make a small sprawling clump. The stems bear peach-colored flowers all summer.

H: 12 in (30 cm), **S**: 12 in (30 cm)
❄❄ ◊ ☼

Short plants for sun (Er–Ge)

Erica carnea '*Foxhollow*'
There are many winter-flowering heathers, but this is a favorite, bearing small, pale pink, bell-shaped flowers throughout the coldest weather. The needlelike, pale green leaves become tinged with red in winter. A good low-growing plant.

H: 8 in (20 cm), **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼

Erigeron karvinskianus
The little Mexican daisy is a welcome plant in many gardens, often growing in gaps in paving or out of dry stone walls—anywhere hot and dry. The small pink-tinged white daisy flowers appear from early summer to winter on low, sprawling plants.

H: 8 in (20 cm), **S**: 24 in (60 cm)
❄❄ ◊ ☼

Erysimum '*Bowles' Mauve*'
This is a superb plant for injecting color into cottage-garden-style plantings in spring and summer. It forms an evergreen, shrubby plant with gray-green leaves. In spring, the flowering stems are soon covered with purple flowers.

H: 24 in (60 cm), **S**: 24 in (60 cm)
❄❄ ◊ ☼













Euphorbia cyparissias '*Fens Ruby*'
This low-growing perennial is a useful, if somewhat invasive, plant, grown for its foliage and spring flowers. In spring, purplish-green shoots appear, producing delicate foliage. As the season progresses, small, lime green flowers develop.

H: 12 in (30 cm), **S**: 6 ft (2 m)
❄❄❄ ◊ ◑ ☼

Euphorbia rigida
This sprawling plant is superb in a sunny rock garden. Fleshy stems arise from a central crown, then grow along the ground in an almost snakelike fashion, holding narrow, triangular blue-silver leaves. Lime green flowers appear in early summer.

H: 8 in (20 cm), **S**: 24 in (60 cm)
❄❄ ◊ ☼

Francoa sonchifolia
In a sunny, warm area, this perennial makes a good ground cover. The fleshy leaves grow from a creeping stem, which in mid- to late summer sends up tall stems, well above the foliage, of pale pink flowers spotted with darker pink.

H: 24 in (60 cm), **S**: 24 in (60 cm)
❄❄ ◊ ☼ ◑

Fuchsia '*Genii*'
This compact, hardy fuchsia is a reliable cultivar. It produces masses of pendent purple and red flowers in late summer and fall, until the first frost. The blooms are held against bright yellow leaves, adding to the plant's impact.

H: 24 in (60 cm), **S**: 24 in (60 cm)
❄❄ ☼ ◑

Gaura lindheimeri
A delicate-looking perennial for the front of a sunny border that produces wands of open, white flowers held on slim stems from midsummer until mid-fall. A hard frost will kill the top growth, but fresh shoots appear in spring if protected in winter.

H: up to 3 ft (1 m), **S**: 3 ft (1 m)
❄❄ ☼

Geranium '*Ann Folkard*'
This hardy geranium is appealing for both flowers and foliage. The leaves are hand-shaped and bright gold in color, especially when young; they become greener as they age. Large, open, bright magenta flowers with dark centers are produced all summer.

H: 24 in (60 cm), **S**: 3 ft (1 m)
❄❄❄ ☼ ◑













Geranium *Rozanne* ('*Gerwat*')
One of the finest of all cranesbills, this selection has trailing, non-rooting stems that cover the ground from late spring, producing masses of large, open, bright blue flowers from early summer well into fall. Cut back stems in winter.

H: 18 in (45 cm), **S**: 24 in (60 cm)
❄❄❄ ☼ ◑

Geum coccineum
This clump-forming perennial is a fine summer-flowering plant. It forms a rosette of toothed green leaves, and attractive, open, saucer-shaped, orange-red flowers with yellow stamens for several weeks. Plants like sun but not overly dry soil.

H: 20 in (50 cm), **S**: 12 in (30 cm)
❄❄❄ ◑ ● ☼ ◑

Geum rivale
A European native, the little water avens is attractive for wet areas, perhaps in wilder patches of the garden. This perennial forms clumps of leaves, and over several weeks in early summer produces dusky pink and red bell-shaped flowers.

H: 20 in (50 cm), **S**: 12 in (30 cm)
❄❄❄ ◑ ● ☼

Short plants for sun (Ha–Pe)

Hakonechloa macra '*Aureola*'
This ornamental grass is a fine garden plant. It forms a low clump of gold and green striped foliage. The plant spreads slowly from slender rhizomes and will grow in a range of situations, including sun, as long as the soil is moist.

H: 12 in (30 cm), **S**: 16 in (40 cm)
❄❄❄ 💧 ◑ ☼ ☼ ☀

Helianthemum '*Rhodanthe Carneum*' ('*Wisley Pink*')
This low-growing plant is ideal for sunny rock gardens. Plants are evergreen with small, oval, silvery foliage. In early summer, silver-pink flowers with a soft yellow eye appear. They last a day, but are produced in profusion.

H: 12 in (30 cm), **S**: 20 in (50 cm)
❄❄❄ 💧 ☼

Hemerocallis '*Golden Chimes*'
A dainty day lily, ideal for the small garden because it is compact and free-flowering. In summer, flowering stems appear from clumps of narrow, arching leaves. The bright yellow, open, trumpet-shaped flowers have brownish-red reverses.

H: up to 3 ft (1 m), **S**: 20 in (50 cm)
❄❄❄ 💧 ☼ ◑













Hypericum olympicum
An ideal plant for open, sunny positions, this low-growing shrub is a fine sight in summer. The small leaves are gray-green and a good foil to the open, starry, golden yellow flowers produced in clusters at the ends of the stems.

H: 12 in (30 cm), **S**: 20 in (50 cm)
❄❄❄ 💧 ☼

Iris unguicularis
Few herbaceous plants are of interest in winter, but this evergreen iris is a stellar performer. For much of the year, it is unremarkable, but in mild spells during winter, delicate lavender-mauve flowers with yellow markings open, lasting several days.

H: 12 in (30 cm), **S**: 24 in (60 cm)
❄❄❄ 💧 ☼

Lychnis flos-cuculi
The ragged robin is a European native. It is a short-lived perennial that sends up tall flowering stems in early summer. The flowers are open, starry, usually pale pink, sometimes white, with long narrow petals. Plants grow well in damp shade.

H: 30 in (75 cm), **S**: 12 in (30 cm)
❄❄❄ 💧 ◑ ☼ ◑

Narcissus '*Jetfire*'
There are many narcissi to choose from, but this selection, with its elegant and brightly colored early spring blooms, is a favorite. The flower petals are rich gold and reflexed, while the trumpet is a contrasting reddish orange.

H: 9 in (22 cm), **S**: 4 in (10 cm)
❄❄❄ ◊ ☼ ◑



Nepeta *x* faassenii
Useful and easy, catmint is a clump-forming plant with spreading stems and blue-green, soft, aromatic foliage that is attractive to cats. In summer, sprays of blue flowers appear. If the plant is cut back after flowering, it will produce a second crop.

H: 20 in (50 cm), **S**: 20 in (50 cm)
❄❄❄ ◊ ☼



Oenothera speciosa
Low-growing and sun-loving, this plant spreads freely at the root, especially in light soil, producing short, upright stems. The large, cup-shaped, pink flowers open from pointed buds and are short-lived, but appear in great profusion throughout summer.

H: 12 in (30 cm), **S**: 20 in (50 cm)
❄❄❄ ◊ ☼





Osteospermum '*Sunny Serena*'
A tender perennial, grown for its dazzling daisy flowers in summer and well into fall, this plant is well suited to container cultivation or filling gaps in sunny beds and borders. Remove blooms as they fade and fertilize regularly if in a pot.

H: 24 in (60 cm), **S**: 12 in (30 cm)
❄ ◊ ☼



Penstemon '*Alice Hindley*'
With its shimmering, pale mauve-violet flowers carried in upright flowerheads, this is one of the most desirable penstemons. Oval leaves are carried on woody stems that should not be cut back until spring, when new shoots arise from the base of the plant.

H: 30 in (75 cm), **S**: 20 in (50 cm)
❄❄ ◊ ☼



Penstemon '*Andenken an Friedrich Hahn*'
A most popular penstemon, this plant is better known as *P.* 'Garnet'. Loose but upright flowerheads of rich red, tubular blooms appear throughout summer and well into fall, until the first frost.

H: 30 in (75 cm), **S**: 24 in (60 cm)
❄❄ ◊ ☼

Short plants for sun (Pe–Za)

Persicaria affinis '*Superba*'
For ground cover, there are few plants to match this perennial, particularly in late summer and fall, when the blooms open pale pink and age to crimson, giving a fine two-tone look on the same plant. Rust-brown leaves carpet the ground in winter.

H: 12 in (30 cm), **S**: 24 in (60 cm)
❄❄❄ ◑ ◊ ☼ ☀

Phlox '*Chattahoochee*'
A low-growing perennial that is ideal for the front of a border or a rock garden. In early summer, flowers are carried in clusters. They are a delightful rich lilac color with a central reddish-purple eye, and are produced in profusion.

H: 12 in (30 cm), **S**: 24 in (60 cm)
❄❄❄ ◊ ☼ ☀

Pittosporum tenuifolium '*Tom Thumb*'
This evergreen makes a great addition to the smaller garden, with its compact form and mahogany-colored foliage. The leaves are particularly attractive in spring as green new growth emerges, giving the plant a two-tone effect.

H: up to 3 ft (1 m), **S**: 24 in (60 cm)
❄❄ ◊ ☼













Pulsatilla vulgaris
The pasque flower is one of the most beautiful spring flowers. The fernlike foliage forms a small clump, while its star-shaped flowers are usually rich purple, but can be pink, red, or white, and have a boss of golden stamens. The plant prefers chalky soil.

H: 12 in (30 cm), **S**: 8 in (20 cm)
❄❄❄ ◊ ☼

Rudbeckia fulgida *var.* sullivantii '*Goldsturm*'
Perennials that flower in fall are valuable, and this plant is also compact. Its daisylike flowers, with narrow, golden petals and a black central cone, open atop sturdy stems, which should be cut to the ground after flowering.

H: 24 in (60 cm), **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼

Sedum '*Herbstfreude*'
With its succulent gray-green stems and foliage, this plant is well adapted to withstand hot sun and drought. In late summer, flat heads of rust red flowers open, lasting for several weeks; the dry flowerheads remain attractive into winter.

H: 24 in (60 cm), **S**: 3 ft (1 m)
❄❄❄ ◊ ☼

Sisyrinchium striatum '*Aunt May*'
This choice plant earns its keep. All year, the rapier-like foliage, striped lengthwise with cream and gray-green, provides striking contrast to more rounded shapes. In early summer, spikes of primrose yellow flowers open in succession.

H: 24 in (60 cm), **S**: 12 in (30 cm)
❄❄ 💧 ☼

Stachys byzantina '*Big Ears*'
This selection of the common lambs' ears has large, oval leaves, which are covered with silvery white "wool." The low-growing plant is particularly attractive at the front of a pale-colored border. In summer, erect spikes of mauve flowers appear.

H: 24 in (60 cm), **S**: 3 ft (1 m)
❄❄❄ 💧 ☼

Stipa tenuissima
This perennial grass is a good choice for the garden, since it is beautiful for much of the year. In spring, the bright green growth is attractive, but in summer, the flowerheads give clumps a fluffy appearance, and as the seeds form, plants become straw-colored.

H: 24 in (60 cm), **S**: 12 in (30 cm)
❄❄ 💧 ☼













Veronica gentianoides '*Tissington White*'
A good plant for early summer, this low-growing perennial carpets the ground with its shiny oval leaves. Numerous spikes of gray-white flowers arise in late spring and remain attractive for several weeks.

H: 24 in (60 cm), **S**: 24 in (60 cm)
❄❄❄ 💧 ◑ ☼

Vinca difformis
Periwinkles are popular ground-covering plants, but this species is more refined than many. The flowers are its main attraction. They are produced through much of winter and spring and are pale blue to nearly white and propeller-shaped.

H: 24 in (60 cm), **S**: 4 ft (1.2 m)
❄❄ 💧 ☼ ◑

Zauschneria californica
Spectacular in flower, this plant needs a hot situation to grow well, but is an excellent choice for a sunny corner. It forms a low plant with small gray-green leaves. In late summer, sprays of vibrant, orange-red flowers appear, each bloom shaped like a small fuchsia.

H: 24 in (60 cm), **S**: 24 in (60 cm)
❄❄ 💧 ☼

Short plants for shade (Al–He)

Alchemilla mollis
Commonly known as lady's mantle, this perennial thrives in the shade. The soft green leaves form a mound of growth, and have a charming way of catching water droplets. In summer, heads of lime green, small flowers appear.

H: 12 in (30 cm), **S**: 24 in (60 cm)
❄❄❄ ◑ ☼

Arum italicum *subsp.* italicum '*Marmoratum*'
This perennial is grown for its winter foliage. Leathery leaves, richly veined in silver-white, appear in late fall. The green flowers in summer are unremarkable, but later displays of red berries (poisonous) are attractive.

H: 24 in (60 cm), **S**: 12 in (30 cm)
❄❄❄ ◊ ◑ ☼

Brunnera macrophylla '*Dawson's White*'
This compact perennial needs a cool, moist position. The hairy, heart-shaped leaves, margined with white, are particularly attractive with the sprays of blue flowers that are carried on stems above the foliage.

H: 12 in (30 cm), **S**: 12 in (30 cm)
❄❄❄ ◊ ◑ ☼













Carex elata '*Aurea*'
With vibrant fountains of rich, golden, grassy foliage, this clump-forming deciduous perennial is a desirable plant for moist, even wet, soil in shade. Here, it shines out from darker plants, especially in spring when the leaves are young.

H: 28 in (70 cm), **S**: 18 in (45 cm)
❄❄❄ ◑ ● ☼

Cornus canadensis
A seldom-seen ground-cover plant that spreads by rhizomes in acidic soil. The leaves are held around short stems, and showy white flowerheads are borne in early summer. Each has four "petals" that are actually bracts, and may be followed by red berries.

H: 8 in (20 cm), **S**: 3 ft (1 m)
❄❄❄ ◑ ☼

Corydalis flexuosa
This dainty perennial is easy to grow in a cool corner. It comes into growth early, fleshy shoots producing fern-like leaves. The electric blue flowers are held in clusters and look rather like shoals of little fish. After flowering, plants often die down quickly.

H: 8 in (20 cm), **S**: 24 in (60 cm)
❄❄❄ ◑ ☼

Cyclamen hederifolium
This is an essential plant for its fall flower displays. The plant grows from a corm just below the surface of the soil, sending up masses of pink or white flowers, followed by attractive leaves that are marked with silver or darker green.

H: 4 in (10 cm), **S**: 8 in (20 cm)
❄❄❄ ◊ ◑ ☼



Daphne laureola *subsp.* philippi
This upright bushy evergreen is slow-growing and suited to the smaller yard. The leaves are shiny and clustered toward the tops of the stems, from where, in late winter, strongly perfumed, green bell-shaped flowers appear, followed by black berries.

H: 24 in (60 cm), **S**: 3 ft (1 m)
❄❄❄ ◊ ◑ ☼



Epimedium *x* versicolor
These easy-to-grow, clump-forming perennials are good for shaded spots under shrubs. The dainty, divided foliage is attractive, especially in spring, and is often bronze-tinged. Clusters of yellow, orange, or pink flowers appear at the same time.

H: 8 in (20 cm), **S**: 12 in (30 cm)
❄❄❄ ◊ ◑ ☼





Galanthus nivalis
The first flowers of the common snowdrop are a sign to gardeners that spring is on the way. These plants grow well in shade and will quickly bulk up to form large clumps, which need to be split regularly to keep them flowering.

H: 4 in (10 cm), **S**: 8 in (20 cm)
❄❄❄ ◊ ◑ ☼



Geranium macrorrhizum
This is one of the lower-growing cranesbills, good for planting under larger shrubs and forming a dense ground cover with its soft aromatic foliage. In spring, short stems produce clusters of pink, mauve, or white flowers over several weeks.

H: 12 in (30 cm), **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼



Helleborus *x* hybridus
Also known as Lenten roses, these perennials are very popular spring plants. In late winter, new shoots emerge; the nodding flowers appear first, followed by the leaves. The flowers come in many colors (but not blue), and they last for weeks.

H: 20 in (50 cm), **S**: 12 in (30 cm)
❄❄❄ ◊ ◑ ☼

Short plants for shade (He–Uv)

Heuchera '*Plum Pudding*'
This foliage plant makes an attractive addition to a shady border. The rounded, evergreen, wavy-edged leaves are purple-red with silver markings that give the plant a metallic shimmer. In summer, spires of flowers are held above the foliage.

H: 24 in (60 cm), **S**: 12 in (30 cm)
❄❄❄ ◊ ◑ ☼

Lysimachia nummularia '*Aurea*'
This perennial's brightly colored foliage means it can be used in the garden to dramatic effect. The golden, oval leaves are held on stems that grow flat on the ground, forming a dense mat. Yellow, cup-shaped flowers appear in summer.

H: 1¼ in (3 cm), **S**: 3 ft (1 m)
❄❄❄ ◊ ◑ ● ☼ ◑

Meconopsis cambrica
The delightful Welsh poppy is a welcome plant in many gardens; its fresh foliage and flowers make a wonderful show in shaded positions. The flowers, carried on slender stems above the leaves, appear in shades of yellow or orange.

H: 20 in (50 cm), **S**: 12 in (30 cm)
❄❄❄ ◊ ◑ ◑













Omphalodes cappadocica '*Cherry Ingram*'
This little perennial is a delight in spring. Its small leaves form a compact clump that starts early into growth. Starry, mauve-blue flowers are carried in small spires and are beautiful for several weeks.

H: 8 in (20 cm), **S**: 12 in (30 cm)
❄❄❄ ◊ ◑ ☼

Ophiopogon planiscapus '*Nigrescens*'
A useful perennial that can be combined with many other plants. It is clump-forming and evergreen with almost black, grasslike foliage. In summer, small, mauve flowers appear, followed by black berries.

H: 6 in (15 cm), **S**: 8 in (20 cm)
❄❄❄ ◊ ◑ ☼

Pachysandra terminalis
This evergreen, ground-covering plant is one of few that will grow in dry shade under shrubs and trees. Its toothed leaves form a mat of growth that prevents weeds; the plant spreads via underground runners. In summer, white flowers appear.

H: 8 in (20 cm), **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼

Primula pulverulenta
This perennial must have moist, rich soil to thrive. The leaves emerge in spring before the flowerheads. The stout stems, which are covered in a chalky white coating, are striking and contrast well with the rounded heads of small, reddish purple blooms.

H: 24 in (60 cm), **S**: 12 in (30 cm)
❄❄❄ ◑ ● ☼

Primula vulgaris
The common primrose is a worthy garden plant and will grow in shady borders under trees and shrubs, in cool rock gardens, or naturalized in grass. In early spring, a succession of yellow, or sometimes white, or even pink, flowers open over many weeks.

H: 6 in (15 cm), **S**: 8 in (20 cm)
❄❄❄ ◑ ☼

Pulmonaria '*Sissinghurst White*'
With attractive, bell-shaped flowers produced over many weeks in spring, and silver-green foliage, these perennials are excellent garden plants. This dependable selection has white flowers that show up well in shade.

H: 8 in (20 cm), **S**: 24 in (60 cm)
❄❄❄ ◑ ☼













Saxifraga fortunei
This perennial is remarkable for its late-flowering habit, although some selections bloom during summer. It is a clump-forming plant with handsome, glossy, hand-shaped leaves. Showy flowerheads of white flowers appear before the frost.

H: 20 in (50 cm), **S**: 12 in (30 cm)
❄❄❄ ◊ ◑ ☼

Tiarella cordifolia
A good ground-cover plant, this perennial spreads from runners, colonizing small areas. The hand-shaped leaves are soft and tinted purple. Small, white, pink-tinged flowers are held in short spires during spring.

H: 8 in (20 cm), **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼

Uvularia grandiflora
A most elegant perennial that bears flowers in mid-spring. Tall, slender stems with oval leaves arise, from which dangle bell-shaped, yellow flowers with long twisted petals. It is not an easy plant and likes cool, moist soil with added organic matter.

H: 24 in (60 cm), **S**: 12 in (30 cm)
❄❄❄ ◊ ◑ ☼

Trees, large shrubs, and hedging

Acer palmatum *'Sango-kaku'*
This elegant Japanese maple is a shade-loving deciduous tree for all seasons. In spring and fall the palmate leaves are distinctly yellow, and in winter the bright lacquer-red stems make a striking feature. Provide shelter and fertile soil.

H: 20 ft (6 m); **S**: 15 ft (5 m)
❄❄❄ ◑ ☼

Amelanchier *x* grandiflora *'Ballerina'*
A small spreading tree for acidic, clay-rich soils and exposed sites. White blossoms smother the bare branches in spring, followed by red, ripening to black, fruits. The oval leaves, bronze-tinted in spring, color red in fall.

H: 20 ft (6 m); **S**: 25 ft (8 m)
❄❄❄ ◑ ☼ ☼

Arbutus unedo
This evergreen with flaky red-brown bark forms a large shrub or small tree in sheltered gardens. Lily-of-the-valley-like blooms appear in early winter, and the rounded fruits, ripening red in fall, give rise to the common name, strawberry tree.

H: 25 ft (8 m); **S**: 25 ft (8 m)
❄❄❄ ◊ ☼













Betula utilis *var.* jacquemontii
For winter garden impact, plant this white-barked Himalayan birch as a multistemmed tree or a cluster of three saplings. Cultivars, including 'Jermyns' and 'Grayswood Ghost', have even brighter bark. Long catkins dangle in early spring.

H: 60 ft (18 m); **S**: 30 ft (10 m)
❄❄❄ ◊ ◑ ☼ ☼

Camellia *x* williamsii
An evergreen, shade-loving shrub that flowers through mid- and late spring and drops its spent flowers neatly. Single to fully double blooms are white through to deep pink, and cultivars are suitable for large pots or as wall shrubs. Requires acidic soil.

H: 6–15 ft (2–5 m); **S**: 3–10 ft (1–3 m) ❄❄❄ ◑ ☼

Cornus controversa *'Variegata'*
Tiered whorls of branches create a distinctive architectural profile, and with bright green and white foliage and flat heads of white flowers in early summer, this charming tree makes a beautiful focal point. Requires neutral to acidic soil.

H: 23 ft (7 m); **S**: 23 ft (7 m)
❄❄❄ ◊ ◑ ☼ ☼

Cornus kousa *var.* chinensis *'China Girl'*
This small conical tree, for neutral to acidic soils, has tiny green flowers in early summer, surrounded by creamy white, petal-like bracts. Fleshy red fruits develop later, followed by purple-red fall leaves.

H: 22 ft (7 m); **S**: 15 ft (5 m)
❄❄❄ ◑ ☼ ◑

Crataegus laevigata *'Paul's Scarlet'*
Like many hawthorns, this hardy tree with a long season of interest is suitable for exposed sites. 'Paul's Scarlet' has a mass of raspberry red blossoms in late spring followed by a crop of red berries loved by birds.

H: 25 ft (8 m); **S**: 25 ft (8 m)
❄❄❄ ◊ ◑ ☼ ◑

Cupressus sempervirens *Stricta Group*
The narrow columns of Italian cypress act like exclamation marks. Informal groups also work well in Mediterranean-style gravel gardens, casting little shade. Maintain a single leading shoot when plants are young.

H: 70 ft (20 m); **S**: 10 ft (3 m)
❄❄❄ ◊ ☼








Fagus sylvatica
Beech makes an excellent hedge or windbreak, holding on to its coppery fall leaves through winter; the new spring foliage is bright green. Plant bareroot hedging between late fall and early spring. Trim once in late summer.

H: 4–20 ft (1.2–6 m); **S**: 4–6 ft (1.2–2 m) ❄❄❄ ◊ ◑ ☼ ◑

Fatsia japonica
The false castor-bean plant is a shade-loving evergreen that adds a tropical or contemporary touch with its glossy, hand-shaped leaves and branched flowerheads in fall. Plant in late spring in a sheltered spot. Remove frost-damaged leaves in spring.

H: 5–12 ft (1.5–4 m); **S**: 5–12 ft (1.5–4 m)
❄❄ ◑ ◑

Ilex *x* altaclerensis *'Golden King'*
Sparkling in winter sunshine with its glossy, almost spineless, yellow-edged leaves, this holly makes a neat conical shape with little pruning. Despite its name, 'Golden King' is female and, with male pollen in the vicinity, produces crops of red berries.

H: 20 ft (6 m); **S**: 13 ft (4 m)
❄❄❄ ◑ ☼ ◑

Trees, large shrubs, and hedging

Magnolia *x* loebneri *'Leonard Messel'*
This rounded tree or large shrub blooms on bare branches in mid-spring. The eye-catching flowers are lilac pink and produced in abundance. Provide fertile, moisture-retentive soil and shelter from wind. Tolerates lime.

H: 25 ft (8 m); **S**: 20 ft (6 m)
❄❄❄ ◑ ☼ ◑

Mahonia x media *'Charity'*
As well as upright flower clusters in late fall and blue-black berries loved by birds, 'Charity' is strikingly architectural, with whorls of large, evergreen, spiny leaves. 'Winter Sun' blooms through winter. Prune lightly after flowering to keep compact.

H: 15 ft (5 m); **S**: 12 ft (4 m)
❄❄❄ ◑ ◑

Malus *x* robusta *'Red Sentinel'*
Crabapples are two-season plants, offering both blossoms and attractive fruits. 'Red Sentinel' is very hardy and bears white flowers in late spring followed by small yellow-red glossy fruits that turn dark red with age and last well into winter.

H: 22 ft (7 m); **S**: 22 ft (7 m)
❄❄❄ ◑ ☼








Photinia *x* fraseri *'Red Robin'*
Although this evergreen can be kept fairly compact through spring and summer pruning, it makes an excellent back-of-border plant or informal hedge. The new growth is bright coppery red and large heads of tiny white flowers appear in late spring.

H: 15 ft (5 m); **S**: 15 ft (5 m)
❄❄❄ ◊ ◑ ☼ ◑

Phyllostachys nigra
Black bamboo produces a column of slender arching stems, glossy black when mature and contrasting with the light green leaves. Associate with other architectural plants or grow in a pot. Thin out weak canes from the base and cut off low side shoots.

H: 10–15 ft (3–5 m); **S**: 6–10 ft (2–3 m)
❄❄❄ ◑ ☼ ◑

Prunus *x* subhirtella *'Autumnalis Rosea'*
Perfect for the smaller garden, this cherry bears tiny clusters of delicate, double pale pink flowers during mild periods from fall through to spring. The leaves are narrow, bronze when young, and the habit airy.

H: 25 ft (8 m); **S**: 25 ft (8 m)
❄❄❄ ◑ ☼

Rhamnus alaternus *'Argenteovariegata'*
A white-variegated form of Italian buckthorn with contrasting black stems, this dense evergreen makes a handsome wall shrub. In a sheltered spot it can also be grown freestanding, or clipped into a broad cone or dome.

H: 15 ft (5 m); **S**: 12 ft (4 m)
❄❄ ☼

Sorbus aria *'Lutescens'*
A compact, oval-headed whitebeam, the unfurling felted leaves are silvery-white, becoming light sage with white undersides. In late spring, prominent clusters of white flowers appear, followed by dark red fruits. An ideal lawn specimen. Tolerates chalk.

H: 30 ft (10 m); **S**: 25 ft (8 m)
❄❄❄ ☼ ◑

Sorbus vilmorinii
This dainty Chinese rowan eventually forms a small tree. The dark, glossy green divided leaves turn rich red-purple in fall, and late spring flowers produce drooping clusters of crimson berries, aging to pink and white. Likes deep, fertile, acidic soil.

H: 15 ft (5 m); **S**: 15 ft (5 m)
❄❄❄ ◑



Taxus baccata
Clipped as a hedge, the shade-loving common yew produces a smooth, dense finish. Cut once in late summer. Plant bare-root plants in the dormant season, ideally before Christmas, and container plants year-round. The whole plant is poisonous.

H: 6–12 ft (2–4 m); **S**: 3–5 ft (1–1.5 m)
❄❄❄ ◑ ☼

Viburnum *x* bodnantense *'Dawn'*
In frost-free periods, from late fall to spring, this upright deciduous shrub produces clusters of pink blooms with a strong scent of sweet almonds. It is happy in clay and requires little pruning. 'Deben' and 'Charles Lamont' are similar cultivars.

H: 10 ft (3 m); **S**: 6 ft (2 m)
❄❄❄ ◑ ☼

Viburnum tinus *'Eve Price'*
This compact and tough evergreen tolerates a wide range of soils and flowers from early winter to mid-spring. Flower clusters are pink in bud, opening white and honey-scented, and these are followed by blue-black berries that are attractive to birds.

H: 10 ft (3 m); **S**: 10 ft (3 m)
❄❄❄ ◑ ☼

Climbers

Clematis *'Bill MacKenzie'*
This vigorous cultivar flowers from midsummer to late fall and bears intriguing "lemon peel" blooms with dark red centers. Fluffy silver seed-heads follow, and the foliage is light green and feathery. Prune stems almost to the ground in early spring.

H: 22 ft (7 m)
❄❄❄ ◑ ☼ ◑

Clematis *'Etoile Violette'*
From midsummer through to fall, violet-purple nodding blooms are produced on the new season's growth. As with all viticella clematis, prune hard in early spring to about 12 in (30 cm) from ground level, just above a pair of fat buds.

H: 15 ft (5 m)
❄❄❄ ◑ ☼ ◑

Clematis *'Markham's Pink'*
This dainty, double-flowered clematis has rose-pink blooms from spring to early summer and silvery ornamental seedheads. It is ideal for decorating a trellis, covering a low wall, or training up a shrub or small tree. Prune only to remove dead stems.

H: 8 ft (2.5 m)
❄❄❄ ◑ ☼ ◑













Clematis *'Perle d'Azur'*
Profuse in bloom, this sky-blue, small-flowered clematis shines from midsummer to fall even on a north-facing wall. Prune back to about 12 in (30 cm) from ground level in spring, just above strong buds. 'Prince Charles' is more compact.

H: 15 ft (5 m)
❄❄❄ ◑ ☼ ●

Euonymus fortunei *'Silver Queen'*
Though usually grown as ground cover, euonymus cultivars will climb walls and fences, self-clinging via aerial roots. 'Silver Queen' makes dense, bushy wall cover, adding light to a shady view, and the white edges turn pink in winter. Trim to neaten.

H: 20 ft (6 m)
❄❄❄ ◊ ◑ ☼ ●

Hedera helix *'Glacier'*
The gray-green, three- to five-lobed leaves of this English ivy are marbled with a variable white margin that is brightest in good light. Self-clinging stems make a close-knit wall or fence covering, and it can be pruned at any time to control spread.

H: 8 ft (2.5 m)
❄❄❄ ◊ ◑ ☼ ◑

Hydrangea anomala *subsp.* petiolaris
Although this deciduous, self-clinging climber takes a few years to begin climbing and flowering in earnest, it is a stunning sight on a shady wall when covered in its white midsummer blooms. It has yellow fall foliage.

H: 50 ft (15 m)
❄❄❄ ◑ ☼ ☀

Parthenocissus henryana
This well-behaved form of Virginia creeper develops silvery veins and red tints in partial shade but has better fall color in full sun, when the leaves turn crimson before falling. It clings to vertical surfaces via sticky-ended tendrils. Prune to control size.

H: 30 ft (10 m)
❄❄❄ ◑ ☼ ☀

Pileostegia viburnoides
An evergreen, self-clinging climber that thrives in sheltered sites on fertile soil. The architectural leaves are long, leathery and pointed and, in late summer and fall, frothy sprays of white flowers appear. May take a few years to reach flowering size.

H: 20 ft (6 m)
❄❄ ◊ ☼ ☀



Schizophragma integrifolium
This self-clinging, deciduous hydrangea relative blooms in midsummer and bears heads of tiny fertile flowers surrounded by showy sterile bracts. *Schizophragma hydrangeoides* 'Roseum' has pink bracts. Shade the roots and provide initial support.

H: 40 ft (12 m)
❄❄ ◑ ☼ ◐

Trachelospermum jasminoides
Confederate or star jasmine is an evergreen twining climber with small, fragrant, white pinwheel blooms in midsummer. Thrives in a hot, sheltered site. Provide wire supports. Growth may be slow at first. *Trachelospermum asiaticum* is similar.

H: 28 ft (9 m)
❄❄ ◊ ☼

Vitus vinifera *'Purpurea'*
The leaves of this deciduous vine are intricately cut and a rich red-purple shade, becoming darker in fall when clusters of unpalatable small, round, purple grapes ripen. Provide support for the tendrils to cling to and plant on fertile soil.

H: 22 ft (7 m)
❄❄❄ ◊ ◑ ☼

Medium-sized shrubs

Acer palmatum *var.* dissectum *Dissectum Atropurpureum Group*
Purple-red, finely cut foliage, which turns a vibrant red in fall, covers the arching stems of this slow-growing deciduous shrub. Like other Japanese maples, it prefers rich, moisture-retentive soil and a sheltered site.

H: 6 ft (2 m); **S**: 10 ft (3 m)
❄❄❄ ◑ ☼ ◑

Aucuba japonica *'Variegata'*
Spotted laurel is a shade-loving evergreen whose gold-splashed leaves lighten gloomy corners. Tolerant of pollution, it is ideal for city gardens. Female forms, like 'Crotonifolia' and 'Variegata', have bright red berries. Remove frost-damaged tips in spring.

H: 10 ft (3 m); **S**: 10 ft (3 m)
❄❄❄ ◊ ◑ ◑

Buddleja *'Lochinch'*
This butterfly bush has silvery-white stems and gray-green leaves that make a lovely foil for the pale lavender flowerheads, which appear from mid- to late summer. Each tiny bloom has an orange "eye." Prune back hard in early spring.

H: 8 ft (2.5 m); **S**: 10 ft (3 m)
❄❄❄ ◊ ☼








Ceanothus *x* delileanus *'Gloire de Versailles'*
A deciduous California lilac, this bushy shrub flowers prolifically from midsummer to mid-fall. The blooms are a soft powder-blue and work well in a mixed border. Prune to a low framework in mid-spring.

H: 5 ft (1.5 m); **S**: 5 ft (1.5 m)
❄❄❄ ◊ ☼

Choisya *'Aztec Pearl'*
This rounded, evergreen Mexican orange blossom has glossy narrow leaves that produce an airy effect. Flowering abundantly in late spring, with a second late-summer show, its star-shaped blooms are pink-tinged white and fragrant.

H: 8 ft (2.5 m); **S**: 8 ft (2.5 m)
❄❄❄ ◊ ◑ ☼ ◑

Choisya ternata *Sundance*
Lime-colored and slow-growing, this popular, neat evergreen makes a vibrant addition to a shady border; it rarely flowers. On drier soils or in full sun, the foliage is golden. Avoid poor soils, and frost-prone or exposed sites. A good container plant.

H: 8 ft (2.5 m); **S**: 8 ft (2.5 m)
❄❄❄ ◊ ◑ ☼ ☀

Cornus alba *'Sibirica'*
This slowly suckering dogwood has red fall foliage and lacquer-red winter stems. Plant in groups for maximum impact, and prune hard in early spring to promote plenty of new growth with vibrant color. Tolerates waterlogged clay.

H: 10 ft (3 m); **S**: 10 ft (3 m)
❄❄❄ ◑ ● ☼ ◑

Cornus alba *'Spaethii'*
Variegated dogwoods provide foliage contrast in mixed borders and help to lighten evergreen plantings. When established, prune out one-third of the oldest growth in early spring to promote the cherry-red winter stems. Remove all-green shoots.

H: 10 ft (3 m); **S**: 10 ft (3 m)
❄❄❄ ◑ ● ☼ ◑

Daphne bholua *'Jacqueline Postill'*
This late-winter-flowering evergreen daphne is hard to beat for fragrance, especially when planted in a spot sheltered from wind. The small but numerous blooms are deep purple-pink outside and white within. Mulch to retain moisture.

H: 6–12 ft (2–4 m); **S**: 5 ft (1.5 m)
❄❄❄ ◑ ☼ ◑








Escallonia laevis *'Gold Brian'*
This compact cultivar is grown mainly for its attractive bright, lime-green to gold, glossy foliage. A reliable evergreen for most gardens, it resents exposure to cold, drying winds. Deep pink blooms are produced during summer. Pruning is rarely required.

H: 4 ft (1.2 m); **S**: 4 ft (1.2 m)
❄❄❄ ◊ ◑ ☼ ◑

Fargesia murielae *'Simba'*
An excellent dwarf form of bamboo, 'Simba' is well behaved either in the border or in a large container. The fluttering leaves clothing the upright stems are a fresh, light green. Thin out weak stems, and some older than three years, to maintain an airy habit.

H: 6 ft (2 m); **S**: 24 in (60 cm)
❄❄❄ ◑ ☼ ◑

Hebe *'Great Orme'*
A long-flowering hebe with tapering, rich pink, fading to white blooms from midsummer to fall. The stems are purple, contrasting attractively with the narrow, glossy, mid-green leaves. Ideal for city or seaside gardens with shelter from cold winds.

H: 4 ft (1.2 m); **S**: 4 ft (1.2 m)
❄❄ ◊ ☼

Medium-sized shrubs

Hebe salicifolia
A hardy species, this narrow-leaved hebe flowers between early summer and mid-fall. Tapering white or lilac-tinged blooms are borne on upright to arching stems clothed in light green leaves. *Hebe* 'Spender's Seedling' is similar but more compact.

H: 8 ft (2.5 m); **S**: 8 ft (2.5 m)
❄❄❄ ☼

Hydrangea arborescens *'Annabelle'*
The blooms of this long-flowering American hydrangea first appear in early summer; they are fresh apple-green in bud, expanding to form very large creamy-white domes. They then make attractive papery heads in fall. Prune lightly in spring.

H: 8 ft (2.5 m); **S**: 8 ft (2.5 m)
❄❄❄ ◑ ☼ ◑

Hydrangea paniculata
With abundant cone-shaped creamy-white heads in late summer, forms of *H. paniculata* are ideal for the mixed border; pink tints often develop in fall, especially in cultivars like 'Unique'. Prune to a low framework each spring for larger blooms.

H: 10 ft (3 m); **S**: 8 ft (2.5 m)
❄❄❄ ◑ ☼ ◑













Hydrangea *'Preziosa'*
This compact hydrangea has dark mahogany stems and red fall tints. Late-summer flowers beautifully combine young, pale pink blooms with mature heads of deep red, tinted purple in acidic soil. Trim shoot tips to the first fat buds in spring.

H: 5 ft (1.5 m); **S**: 5 ft (1.5 m)
❄❄ ◑ ☼ ◑

Hydrangea serrata *'Bluebird'*
A lacecap type with narrow, tapered leaves, this dainty hydrangea bears porcelain-blue heads over a long period through summer into fall. 'Grayswood', with mauve blooms, acquiring raspberry tints in fall, is slightly taller at 6 ft (2 m).

H: 4 ft (1.2 m); **S**: 4 ft (1.2 m)
❄❄ ◑ ☼ ◑

Juniperus *x* pfitzeriana *'Sulphur Spray'*
The arching to upright branches of this juniper are covered in feathery sprays of pale sulfur-tinted foliage, the coloring most pronounced at the shoot tips. Stems may be removed to control height and spread.

H: 5 ft (1.5 m); **S**: 5 ft (1.5 m)
❄❄❄ ☼ ◑ ☼

Nandina domestica
Heavenly bamboo is an evergreen or semievergreen shrub with upright stems. The divided leaves are tinted coppery red when young and develop strong red-purple tones in winter. Midsummer flower sprays are white, developing into orange-red berries.

H: 6 ft (2 m); **S**: 5 ft (1.5 m)
❄❄ ◑ ☼

Olearia *x* haastii
This small-leaved evergreen is neat and compact and thrives in sheltered urban gardens or in seaside areas. The leathery leaves have a white felted reverse. Frothy heads of tiny white, yellow-centered daisies appear between mid- and late summer.

H: 6 ft (2 m); **S**: 10 ft (3 m)
❄❄ ◊ ☼

Osmanthus *x* burkwoodii
In mid-spring this small-leaved evergreen is smothered in clusters of tiny white tubular blooms with a strong perfume. A compact shrub, it doesn't require pruning but can be clipped immediately after flowering to form simple topiary shapes.

H: 10 ft (3 m); **S**: 10 ft (3 m)
❄❄❄ ◊ ◑ ☼ ◑













Phormium *'Alison Blackman'*
A New Zealand flax with olive-green-centered leaves carrying gold stripes with a narrow red margin. Tall flower shoots sometimes appear in summer. Tougher than many other colored-leaf cultivars. 'Sundowner' has similar coloring but is larger.

H: 4½ ft (1.4 m); **S**: 4½ ft (1.4 m)
❄❄ ◊ ◑ ☼

Phormium tenax *Purpureum Group*
Ideal for a dramatic focal point in the border, members of this group have tapering, strap-shaped leaves that arch at the tip and, when mature, produce towering, rodlike flower stems. The cultivars 'Platt's Black' and 'All Black' are particularly dark.

H: 6 ft (2 m); **S**: 8 ft (2.5 m)
❄❄ ◊ ◑ ☼

Physocarpus opulifolius *'Diabolo'*
Use this dark-purple-leaved form of the deciduous ninebark for foliage contrast in the mixed border. The leaves are trilobed and toothed, and in early summer dome-shaped heads of pale pink blooms appear. Spring-prune for larger leaves.

H: 6–8 ft (2–2.5 m); **S**: 8 ft (2.5 m)
❄❄❄ ◊ ◑ ☼ ◑

Medium-sized shrubs

Pittosporum *'Garnettii'*
These New Zealand natives make useful evergreen backdrops or wall shrubs for sheltered town gardens and seaside plots. 'Garnettii' has mahogany stems with gray-green, white-edged leaves, pink-tinged in winter, and dark purple, scented spring blooms.

H: 10 ft (3 m); **S**: 6 ft (2 m)
❄❄ ☼

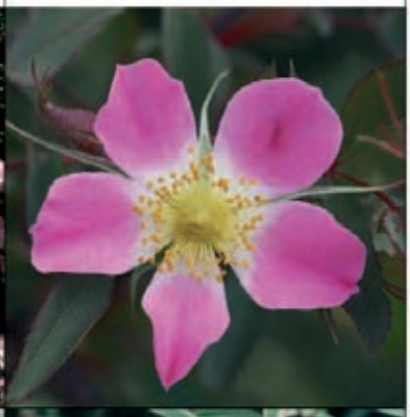
Rhododendron yakushimanum
An evergreen for acidic soil that makes a neat dome shape. It produces rose-pink buds in spring that open to large heads of white and pale pink bell-shaped blooms. The new leaf growth, covered in a colorful felting of light cinnamon, is also a feature.

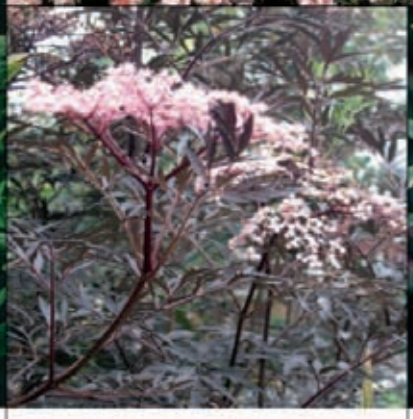
H: 6 ft (2 m); **S**: 6 ft (2 m)
❄❄❄ ◑ ☼ ☼

Rosa glauca
Even when not in flower, this shrub rose makes an attractive foil for flowers in the mixed border. Arching red-purple stems bear soft purple-gray leaves and, in summer, single cerise-tinted blooms appear, later producing dark red spherical hips.

H: 6 ft (2 m); **S**: 5 ft (1.5 m)
❄❄❄ ◑ ☼ ☼








Rosa rugosa *'Alba'*
A shrub rose with apple-green, virtually disease-free foliage and yellow fall color. All summer, flushes of large, single, fragrant white blooms appear, each with a yellow eye. Showy tomato-red hips follow, which are attractive to finches.

H: 6 ft (2 m); **S**: 6 ft (2 m)
❄❄❄ ◑ ☼ ☼

Sambucus nigra *'Black Lace'* (syn. *'Eva'*)
Aptly named, this deciduous elderberry has finely-cut, purple-black foliage and, if only lightly pruned, flat plates of pink summer blossoms and black berries. Prune to a low framework in early spring to keep compact.

H: 10 ft (3 m); **S**: 10 ft (3 m)
❄❄❄ ◑ ☼ ☼

Sarcococca hookeriana *var.* digyna
The upright stems of this suckering evergreen shrub are clothed in shiny, narrow, tapering leaves. In winter, tiny blooms with tufts of cream anthers release a pervasive perfume, giving rise to the common name of sweet box. Shiny black berries follow.

H: 5 ft (1.5 m); **S**: 6 ft (2 m)
❄❄❄ ◑ ☼ ☼

Skimmia japonica *'Rubella'*
This glossy, evergreen woodlander has showy cones of crimson flower buds that develop in fall and open to sweetly fragrant white blooms in spring. This cultivar is male, so it does not produce berries. It is slow-growing, and needs shelter and fertile soil.

H: 5 ft (1.5 m); **S**: 5 ft (1.5 m)

Syringa meyeri *'Palabin'*
This dwarf lilac has fragrant, lavender-pink blooms in late spring and early summer and small oval leaves. It thrives in neutral to alkaline soil. *Syringa pubescens* subsp. *microphylla* 'Superba' flowers intermittently from spring to fall.

H: 6 ft (2 m); **S**: 5 ft (1.5 m)

Taxus baccata *'Standishii'*
Ideal for lightening a shady area or as a focal point among ground cover, this golden-leaved yew makes a compact column over time. Prune back competing leading shoots to reduce spread. *Taxus baccata* 'Fastigiata Aureomarginata' is larger.

H: 5 ft (1.5 m); **S**: 24 in (60 cm)













Viburnum *x* burkwoodii *'Anne Russell'*
In mid- and late spring this compact, deciduous viburnum produces domed heads of waxy-textured, sweetly fragrant blooms that are pink in bud, opening white. Red fruits and colorful tints feature in fall.

H: 6 ft (2 m); **S**: 5 ft (1.5 m)

Viburnum davidii
This evergreen has handsome dark leaves, held on red leaf stalks, with distinctive, deeply grooved, parallel veins giving a pleated effect. Small flower clusters in late spring produce lustrous blue berries on female shrubs when both sexes are present.

H: 3 ft (1 m); **S**: 5 ft (1.5 m)

Weigela florida *'Foliis Purpureis'*
The bronzy-purple foliage of this compact, deciduous weigela is its main feature. In late spring and early summer, clusters of crimson buds open to funnel-shaped blooms with pale pink interiors, and these contrast well with the dark leaves.

H: 3 ft (1 m); **S**: 5 ft (1.5 m)

Low shrubs, shorter perennials, and ground-cover plants

Acorus gramineus *'Ogon'*
This variegated Japanese rush produces fans of grassy foliage with bold gold and green stripes. Often grown as a marginal plant in ponds, this variety also thrives in fertile, moisture-retentive soil and makes an excellent foliage container plant.

H: 10 in (25 cm); **S**: 6 in (15 cm)
❄❄❄ ◑ ● ☼ ☀

Anaphalis triplinervis *'Sommerschnee'*
Pearly everlasting is a clump-forming perennial with felted, gray-green, lance-shaped leaves. From mid-to late summer it bears ball-shaped flowers made of pure white papery bracts. Avoid very dry soil in summer.

H: 28 in (70 cm); **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼ ☀

Armeria maritima
Varieties of sea pink or thrift are drought-tolerant evergreens that make fine grassy tussocks. The abundant white, pink, or red-purple flowers of *A. maritima* are borne in spherical clusters between late spring and early summer.

H: 8 in (20 cm); **S**: 12 in (30 cm)
❄❄❄ ◊ ☼








Artemisia schmidtiana *'Nana'*
Both the species and the dwarf form 'Nana' create low domes of bright, silvery-green, filigree foliage. Close-planted to form an evergreen carpet, they are ideal as drought-tolerant ground cover or to front a dry border. The flowers are insignificant.

H: 3 in (8 cm); **S**: 12 in (30 cm)
❄❄❄ ◊ ☼

Artemisia stelleriana *'Boughton Silver'*
The white-felted foliage of this low evergreen is intricately cut and looks more like lace than leaves. Use it to fill gaps between other plants, especially toward the front of the border, or to provide textural contrast in a container.

H: 6 in (15 cm); **S**: 18 in (45 cm)
❄❄❄ ◊ ☼

Arum italicum *'Marmoratum'*
From late fall through to mid-spring, the marbled, arrow-shaped leaves of lords and ladies cover the ground. In spring, pale green flowers appear, followed by gleaming spikes of fall berries. Good on heavier soils, it needs moisture in sunshine.

H: 12 in (30 cm); **S**: 6 in (15 cm)
❄❄❄ ◑ ☼ ☀

Astilbe *'Bronce Elegans'*
This pretty, dwarf astilbe has finely cut, rich copper foliage in spring and feathery pink plumes from mid- to late summer. Plants form creeping herbaceous colonies and are suitable for the front of a border. Tolerates full sun given plentiful moisture.

H: 12 in (30 cm); **S**: 10 in (25 cm)
❄❄❄ ◑ ● ☼ ☀

Bergenia cordifolia *'Purpurea'*
This evergreen elephant's-ears has magenta bell-shaped flowers in late winter and rich purple-red leaf tones through fall and winter. Its large, glossy, rounded leaves make a strong contrast with grassy foliage plants. *Bergenia purpurascens* is similar.

H: 24 in (60 cm); **S**: 30 in (75 cm)
❄❄❄ ◑ ☼ ☀

Carex flagellifera
One of the New Zealand sedges, this evergreen has upright then arching clumps of fine wiry foliage, tinted gingery-brown. Plant singly to accent low creepers, or in multiples for ground cover with a contemporary look. *Carex testacea* is similar.

H: 3½ ft (1.1 m); **S**: 36 in (90 cm)
❄❄❄ ◑ ☼ ☀













Carex oshimensis *'Evergold'*
This bright, gold and green-striped evergreen sedge from Japan makes hummocks of narrow, arching, grassy leaves. Planted in groups, it provides colorful ground cover, but it also works well in containers. Remove or trim brown leaves in spring.

H: 12 in (30 cm); **S**: 14 in (35 cm)
❄❄❄ ◑ ☼ ●

Ceratostigma plumbaginoides
This creeping plant attracts the eye in late summer when the red stems are studded with gentian-blue blooms. In fall, the carpet of bright green leaves turn red or purple, providing a striking foil for the remaining flowers. Avoid very poor dry soils.

H: 18 in (45 cm); **S**: 12 in (30 cm)
❄❄❄ ◊ ◑ ☼

Cistus *x* dansereaui *'Decumbens'*
From late spring to midsummer, this rock rose produces a succession of pure white, tissue-paper blooms marked with maroon blotches. The sticky evergreen foliage makes fine ground cover for banks and hot, dry borders. *Cistus* x *hybridus* is similar.

H: 24 in (60 cm); **S**: 36 in (90 cm)
❄❄ ◊ ☼

Low shrubs, shorter perennials, and ground-cover plants

Cistus *x* lenis *'Grayswood Pink'*
Blooming in summer, this pretty pink-flowered rock rose is one of the hardiest in cultivation. Low-growing, it spreads to cover a large area, sometimes rooting where the stems touch the ground. Useful for gravel gardens, walls, and banks.

H: 12 in (30 cm); **S**: 10 ft (3 m)
❄❄❄ ☼

Convolvulus cneorum
With leaves like strips of silvery metal, this compact, dome-shaped evergreen gleams in sunshine. Starting in spring, flushes of pink buds open to white funnel-shaped blooms. Thrives in shelter in poor, slightly alkaline soil with sharp winter drainage.

H: 24 in (60 cm); **S**: 36 in (90 cm)
❄❄ ☼

Cotoneaster horizontalis
This tough, deciduous shrub produces a herringbone pattern of branches clothed in small, glossy, dark green leaves that turn red in fall. In late spring, it is smothered in tiny blossoms that ripen to long-lasting red berries. It makes good ground or wall cover.

H: 4 ft (1.2 m); **S**: 5 ft (1.5 m)
❄❄❄ ◑ ☼













Cyclamen hederifolium
Carpets of this self-seeding cyclamen steadily build up under established trees and shrubs, thriving in soil rich in leafmold. The delicate pink blooms appear in fall before the marbled, arrow-shaped leaves, which last throughout winter and spring.

H: 5 in (13 cm); **S**: 6 in (15 cm)
❄❄❄ ◑

Diascia barberae *'Blackthorn Apricot'*
Providing summer-flowering ground cover in well-drained gardens, several diascias are hardy, especially the brick-pink 'Ruby Field', but need plentiful summer moisture. Clip over in spring. They overwinter best in containers.

H: 10 in (25 cm); **S**: 20 in (50 cm)
❄❄ ◑ ☼

Dicentra *'Stuart Boothman'*
This low-growing bleeding heart has feathery blue-gray foliage and, from mid-spring to late summer, arching sprays of deep pink blooms. It prefers fertile, moisture-retentive soil, conditions that prolong both flowering and foliage displays.

H: 12 in (30 cm); **S**: 16 in (40 cm)
❄❄❄ ◑

Erica carnea *'Springwood White'*
Between midwinter and mid-spring, the carpet of emerald-green foliage is covered in tiny, white, honey-scented flowers that attract early bees. It has a trailing habit. Another excellent white is *Erica* x *darleyensis* 'Silberschmelze'. Clip after flowering.

H: 6 in (15 cm); **S**: 18 in (45 cm)
❄❄❄ ◊ ◑ ☼

Erigeron karvinskianus
This dainty fleabane self-seeds freely, growing in cracks in walls and paving and forming colonies in gravel. All summer, a profusion of little daisylike blooms are produced; these mature from white through to deep pinky-purple, creating a two-tone effect.

H: 6 in (15 cm); **S**: 3 ft (1 m)
❄❄❄ ◊ ☼

Euonymus fortunei *'Emerald 'n' Gold'*
With copious gold variegation, this evergreen shrub is ideal for a winter border. As temperatures plummet, the foliage becomes pink-tinged. May be clipped to simple shapes. 'Canadale Gold' is similar but stronger growing.

H: 24 in (60 cm); **S**: 36 in (90 cm)
❄❄❄ ◑ ☼ ◑



Geranium *'Ann Folkard'*
From midsummer to mid-fall, this cranesbill's trailing stems produce vivid magenta-purple blooms, each with a prominent black eye. The deeply cut, five-lobed leaves are a bright lime green. Foliage darkens with age and in excessive shade.

H: 24 in (60 cm); **S**: 3 ft (1 m)
❄❄❄ ◑ ☼ ◑

Geranium *'Johnson's Blue'*
A firm favorite with gardeners, this light-lavender-blue-flowered cranesbill is easy to please and blooms from late spring well into summer. The dish-shaped flowers are enhanced by prominent pinky-blue centers. *G.* 'Rozanne' is longer in bloom.

H: 18 in (45 cm); **S**: 30 in (75 cm)
❄❄❄ ◑ ☼ ◑

Geranium sanguineum
The bloody cranesbill forms neat hummocks of finely cut leaves and bears small magenta-pink flowers for many weeks in summer. Ideal for gravel gardens and raised beds, it also provides good fall color. 'Album' is white-flowered.

H: 8 in (20 cm); **S**: 12 in (30 cm)
❄❄❄ ◊ ◑ ☼ ◑

Low shrubs, shorter perennials, and ground-cover plants

Hakonechloa macra *'Aureola'*
The arching, ribbonlike leaves of this Japanese grass are striped yellow and lime green, developing red tints in full sun, and becoming greener in deep shade. Best in slightly acidic soil and excellent in containers. Cut back foliage in spring.

H: 14 in (35 cm); **S**: 16 in (40 cm)
❄❄❄ ◑ ☼ ☀

Hebe cupressoides *'Boughton Dome'*
A remarkably hardy, neat evergreen with gray-green foliage in the form of overlapping scales. The domed shape contrasts well with narrow-leaved ground cover; or plant it in groups to create a repeating pattern.

H: 12 in (30 cm); **S**: 24 in (60 cm)
❄❄❄ ◊ ☼

Hebe *'Red Edge'*
The gray-green leaves of this small-leaved, hardy hebe are edged with a fine red line and become red-tinged in winter. Small, lilac-blue flowers appear in summer, unless plants have been clipped over in late spring to enhance the domed form.

H: 18 in (45 cm); **S**: 24 in (60 cm)
❄❄❄ ◊ ☼








Hedera helix *'Parsley Crested'*
Non-variegated ivies are useful for covering the dry ground beneath trees, or for making a lawn substitute surrounded by paving. 'Parsley Crested' has mid-green leaves with an undulating margin. 'Manda's Crested' is similar but copper-tinted in winter.

H: 8 in (20 cm); **S**: 6 ft (2 m)
❄❄❄ ◊ ◑ ☼ ☀

Hedera helix *'Little Diamond'*
An aptly named ivy, perfect for the front of a border or edging a container. The small, diamond-shaped leaves are marbled gray-green with a creamy-white edge. A compact, slow-growing plant, it provides dense, bushy cover.

H: 3 in (8 cm); **S**: 12 in (30 cm)
❄❄❄ ◊ ◑ ☼ ☀

Helleborus *x* hybridus
This group of mostly evergreen perennials flowers from midwinter to mid-spring in colors from white, through pinks and reds, to dark maroon. Centers are usually speckled. Remove withered foliage. Prefers heavy, fertile, moisture-retentive soil.

H: 18 in (45 cm); **S**: 18 in (45 cm)
❄❄❄ ◑ ◑ ☀

Heuchera *'Plum Pudding'*
A compact evergreen perennial with heart-shaped, lobed leaves colored red-purple with deeper veining. From late spring, dark wiry stems carry tiny white flowers. 'Pewter Moon' has purple leaves overlaid with silver. Susceptible to vine weevil.

H: 16 in (40 cm); **S**: 12 in (30 cm)
❄❄❄ ◑ ☼ ◑

Hosta *'Halcyon'*
An elegant hosta with tapered, slug-resistant, gray-blue leaves and soft lavender summer flowers. The blue hostas 'Krossa Regal' and 'Big Daddy', and the yellow-centered 'Great Expectations', are also slug-resistant. For added protection, grow in pots.

H: 16 in (40 cm); **S**: 28 in (70 cm)
❄❄❄ ◑ ● ◑ ●

Juniperus squamata *'Blue Carpet'*
This blue-leaved conifer makes a dense evergreen, weed-suppressing carpet and ultimately needs room to spread. It tolerates thin, chalky soil and requires minimal care, but may be pruned to control its spread by cutting out whole branches.

H: 12 in (30 cm); **S**: 6 ft (2 m)
❄❄❄ ◊ ◑ ☼













Lavandula angustifolia *'Hidcote'*
One of the best dwarf lavenders, 'Hidcote' makes mounds of silvery gray leaves topped in midsummer by dark purple spikes. To keep plants bushy and well clothed in foliage, clip over with shears after flowering. 'Munstead' is similar but paler.

H: 24 in (60 cm); **S**: 30 in (75 cm)
❄❄❄ ◊ ☼

Leucothoe *Scarletta* (syn. *'Zeblid'*)
This member of the heather family has small, glossy, evergreen leaves that turn a rich bronze red in fall, and it produces equally colorful new foliage. It requires fertile, acidic, moisture-retentive soil and shelter from wind. A good container plant.

H: 24 in (60 cm); **S**: 3½ ft (1.1 m)
❄❄❄ ◑ ☼

Libertia peregrinans
A slow-spreading grassy evergreen from New Zealand with amber-tinged foliage that brightens in winter, and white, starry spring blooms. The warm-brown-leaved 'Taupo Sunset' is an eye-catching newcomer with contrasting white flowers.

H: 20 in (50 cm); **S**: 20 in (50 cm)
❄❄ ◊ ◑ ☼ ◑

Low shrubs, shorter perennials, and ground-cover plants

Liriope muscari
Lilyturf is a hard-working evergreen perennial that makes a slow-spreading tuft of narrow, leathery, strap-shaped leaves. In late summer, long-lasting spikes of violet-purple flowers emerge. Good as fall-interest path edging or shady ground cover.

H: 12 in (30 cm); **S**: 18 in (45 cm)
❄❄❄ ◊ ◑ ☼ ☀

Muscari armeniacum
Grape hyacinth flowers in mid-spring, attracting early bees with its honey-scented blooms. The dense spikes of blue flowers emerge through grassy carpets. Unusually, this bulb's leaves appear in late summer and last until late spring. 'Blue Spike' is a double.

H: 8 in (20 cm); **S**: 2 in (5 cm)

Narcissus *'February Gold'*
Dwarf, cyclamineus daffodils are invaluable for creating early spring color, and most naturalize well in informal lawns and under trees. With the narrow foliage dying down gracefully, they are also suitable for borders, even in heavy soil.

H: 12 in (30 cm); **S**: 3 in (8 cm)
❄❄❄ ◑ ☼ ☀








Ophiopogon planiscapus *'Nigrescens'*
Black mondo grass, actually a member of the lily family, makes a spreading carpet of virtually black, strappy leaves. Tolerating a wide range of conditions, it keeps its color well even in dry shade.

H: 8 in (20 cm); **S**: 12 in (30 cm)
❄❄❄ ◊ ◑ ☼ ☀

Origanum laevigatum *'Herrenhausen'*
This pretty ornamental oregano is a drought-buster. With purple-tinged leaves and stems, it makes excellent edging. From midsummer, it produces small, rounded heads of pink blooms followed by pretty seedheads.

H: 18 in (45 cm); **S**: 18 in (45 cm)
❄❄❄ ◊ ☼

Osteospermum jucundum
This South African daisy bears long-stemmed flowers, with a darker "eye" and smoky reverse, through summer and into fall. The evergreen carpeting foliage can be used to flow over the edge of retaining walls or to soften paving on a hot, sunny patio.

H: 20 in (50 cm); **S**: 36 in (90 cm)
❄❄❄ ◊ ☼

Pachysandra terminalis *'Variegata'*
The cream-variegated form of this glossy-leaved, evergreen ground cover is slightly slower-growing than the species and useful for lightening areas in dappled shade beneath trees or shrubs. Best given shelter and acidic, moisture-retentive soil.

H: 10 in (25 cm); **S**: 24 in (60 cm)
❄❄❄ ◑ ☼ ☀

Penstemon *'Evelyn'*
Unlike most border penstemons, this evergreen, narrow-leaved perennial is compact and ideal for edging a bed or for planting in pots. The rose-pink tubular blooms continue from midsummer into fall, especially with frequent deadheading.

H: 24 in (60 cm); **S**: 12 in (30 cm)
❄❄❄ ◊ ☼

Persicaria affinis *'Superba'*
This creeping knotweed produces mini pokers of crimson-opening-to-pink blooms from midsummer to fall. The neat carpet of foliage turns brown in winter but remains attractive. Good between rocks and for fronting shrub borders.

H: 10 in (25 cm); **S**: 24 in (60 cm)
❄❄❄ ◑ ☼ ☼








Phormium *'Bronze Baby'*
A dwarf New Zealand flax, this cultivar has deep purple, arching, strap-shaped leaves that form bold tufts among low-growing plants. It is also excellent for providing height in containers. Protect from sharp frost with a thick mulch of bark.

H: 32 in (80 cm); **S**: 32 in (80 cm)
❄❄ ◊ ◑ ☼

Pieris japonica *'Purity'*
Many varieties of *Pieris japonica* are compact and ideal for urban gardens. 'Purity' produces upright sprays of white, lily-of-the-valley flowers in spring and pale green new leaves in whorls at the shoot tips. Provide acidic soil and avoid frosty sites.

H: 36 in (90 cm); **S**: 36 in (90 cm)
❄❄❄ ◑ ☼ ☼

Pinus mugo *'Mops'*
This slow-growing, dwarf mountain pine is almost spherical in habit, with multiple upright stems that are covered in long, evergreen, needle-like leaves. Perfect for gravel-mulched gardens with rocks and pebbles, or as specimens in containers on the patio.

H: 24 in (60 cm); **S**: 36 in (90 cm)
❄❄❄ ◊ ☼

Low shrubs, shorter perennials, and ground-cover plants

Polystichum setiferum ***Divisilobum Group***
This evergreen soft shield fern has highly dissected, dark green fronds with a felted texture. It makes an attractive sculptural feature in winter shade borders and containers. Remove tired fronds in spring.

H: 28 in (70 cm); **S**: 28 in (70 cm)
❄❄❄ ◑ ☼ ☀

Potentilla fruticosa ***'Primrose Beauty'***
Shrubby cinquefoil does well in clay, and soft-colored cultivars also enjoy partial shade. This compact, gray-green-leaved form flowers from summer to fall. Prune in spring, removing a third of the oldest stems.

H: 24 in (60 cm); **S**: 36 in (90 cm)
❄❄❄ ◑ ☼ ◑

Rhodanthemum hosmariense
Almost never out of flower, this silver-green, filigree-leaved evergreen produces most of its daisylike blooms from early to late summer. Use it to soften the edge of a sunny retaining wall, or in gaps in paving, and in poor, stony soil.

H: 12 in (30 cm); **S**: 12 in (30 cm)
❄❄❄ ◊ ☼













Rhododendron ***'Vuyk's Scarlet'***
This dwarf evergreen has a low profile, making it ideal for the front of a shrub border in acidic soil. The scarlet-tinged crimson blooms are single bells with wavy margins and are produced in abundance during mid- or late spring. Tolerates sun.

H: 30 in (75 cm); **S**: 4 ft (1.2 m)
❄❄❄ ◑ ☼ ◑

Rosa ***Surrey***
One of the best of the County series, this ground-cover rose bears double pink, lightly fragrant blooms in flushes between midsummer and fall. Relatively disease-free. Cut plants back in spring with a hedge trimmer. Also try the Flower Carpet series.

H: 32 in (80 cm); **S**: 4 ft (1.2 m)
❄❄❄ ◑ ☼

Scabiosa ***'Butterfly Blue'***
'Butterfly Blue', and the lilac-pink 'Pink Mist', are dainty mini scabious, flowering over a long period through summer into fall, especially if deadheaded regularly. Plant at the border edge or in containers. The flowers attract bees and butterflies.

H: 16 in (40 cm); **S**: 16 in (40 cm)
❄❄❄ ◊ ☼

Sedum *'Ruby Glow'*
Carpeting stonecrops, like 'Ruby Glow' and 'Vera Jameson', combine dusky purple-tinged succulent leaves with crimson flowerheads that appear from midsummer to fall. Effective *en masse* in gravel gardens. Drought-resistant and attractive to butterflies.

H: 10 in (25 cm); **S**: 18 in (45 cm)
❄❄❄ ☼ ◑

Sempervivum tectorum
Common houseleek, also named hen-and-chicks as the rosettes of leaves are surrounded by offshoots, bears upright, red-purple flower stems in summer; the leaves may also be red-tinted. These evergreen succulents are used for living roofs.

H: 6 in (15 cm); **S**: 20 in (50 cm)
❄❄❄ ☼

Sisyrinchium striatum *'Aunt May'*
This cultivar produces white-striped evergreen leaf fans from which upright stems of creamy flowers arise in summer. Architectural in character, they work well planted in swaths in gravel gardens. Deadhead to prevent seeding.

H: 20 in (50 cm); **S**: 10 in (25 cm)
❄❄❄ ☼













Stipa tenuissima
Although this diaphanous grass makes a good pot specimen, it works best weaving through borders or planted in clumps near paving. It bears pale, biscuit-colored flower stems through summer, and the light green leaves fade but remain attractive all winter.

H: 24 in (60 cm); **S**: 12 in (30 cm)
❄❄❄ ☼

Yucca filamentosa *'Bright Edge'*
This brightly variegated form of Adam's needle is best planted as a single specimen or in small groups mulched with gravel or pebbles. Spires of creamy bells may appear in summer, but this is chiefly an evergreen foliage plant. Makes a fine container specimen.

H: 30 in (75 cm); **S**: 4 ft (1.4 m)
❄❄❄ ☼

Yucca flaccida *'Ivory'*
These architectural evergreens can be temperamental about blooming, but 'Ivory' produces its exotic-looking flowers freely. In summer, tall stems bearing a profusion of green-tinted cream bells rise from the basal rosette of blue-green, swordlike leaves.

H: 22 in (55 cm); **S**: 5 ft (1.5 m)
❄❄❄ ☼

Perennials and ornamental grasses

Acanthus spinosus
This statuesque perennial sends up glossy leaves in early spring that expand to form a mound of deeply toothed blades armed with spines. In early summer, spires of white-hooded blooms with long-lasting purple bracts appear. A paving or gravel specimen.

H: 4½ ft (1.4 m); **S**: 36 in (90 cm)
❄❄❄ ◊ ◑ ☼ ☼

Agapanthus *'Loch Hope'*
This Nile lily has clumps of strap-shaped leaves and tall stems topped with striking round heads of deep blue flowers. Combining well with hot-colored blooms, they brighten flagging displays in late summer and early fall. Mulch in winter.

H: 4 ft (1.2 m); **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼

Allium hollandicum *'Purple Sensation'*
In early summer, this ornamental onion bears drumstick heads of rich purple above a tuft of gray-green leaves. The sculptural seedheads are long-lasting and good for drying, but seedlings will produce paler blooms.

H: 3 ft (1 m); **S**: 3 in (7 cm)
❄❄❄ ◊ ☼ ☼













Anemanthele lessoniana
The pheasant's-tail grass, formerly *Stipa arundinacea*, makes a dense clump of narrow, ribbonlike foliage. Arching purple-tinted flower stems reach almost to the ground and, from fall through winter, the olive leaves are tinted orange and red.

H: 36 in (90 cm); **S**: 4 ft (1.2 m)
❄❄❄ ◊ ◑ ☼ ☼

Anemone hupehensis *'Hadspen Abundance'*
An upright, free-flowering perennial that bears unevenly shaped, deep pink blooms with golden stamens from mid- to late summer. The vine-like leaves form substantial clumps. Also try *Anemone* x *hybrida* cultivars.

H: 36 in (90 cm); **S**: 16 in (40 cm)
❄❄❄ ◑ ☼ ☼

Aster *x* frikartii *'Mönch'*
Superior to most Michaelmas daisies, this adaptable lavender-blue aster blooms from midsummer to fall. It doesn't usually need staking and has good mildew resistance. Working well with most color schemes, it is also charming with ornamental grasses.

H: 28 in (70 cm); **S**: 16 in (40 cm)
❄❄❄ ◑ ☼ ☼

Astrantia *'Hadspen Blood'*
This easy-care perennial colonizes wilder parts of the garden in dappled shade but is just as valuable in the early- and midsummer border. The dark red blooms are like tiny posies surrounded by papery bracts, and the leaves are attractively lobed.

H: 36 in (90 cm); **S**: 18 in (45 cm)
❄❄❄ ◑ ☼ ◑

Calamagrostis *x* acutiflora
A strikingly erect grass with a strong winter presence. Popular cultivars include the arching, cream-striped 'Overdam' and the taller 'Karl Foerster', which in midsummer bears pinkish-brown plumes. In fall, both take on bronze or biscuit tones.

H: 5 ft (1.5 m); **S**: 24 in (60 cm)
❄❄❄ ◑ ☼ ◑

Centranthus ruber
The red valerian is a drought-tolerant, fleshy-leaved self-seeder that blooms from late spring to late summer. The cone-shaped crimson flower clusters are great butterfly attractors. It benefits from deadheading. 'Albus' is white.

H: 36 in (90 cm); **S**: 36 in (90 cm)
❄❄❄ ◊ ☼








Chelone obliqua
This turtlehead is a hardy late-summer-flowering perennial that tolerates clay soil and occasional waterlogging. The upright flower stems bear curious pink blooms that open from tightly clustered buds. *Chelone leyonii* is similar but taller. Protect from slugs.

H: 24 in (60 cm); **S**: 12 in (30 cm)
❄❄❄ ◑ ● ☼ ◑

Deschampsia cespitosa
Varieties of the tufted hair grass, such as 'Goldschleier' (syn. 'Golden Veil'), form clumps of narrow, evergreen leaves that produce gracefully arching flower stems in early summer. The airy flowerheads catch the breeze and remain attractive well into fall.

H: 4 ft (1.2 m); **S**: 4 ft (1.2 m)
❄❄❄ ◑ ☼ ◑

Dryopteris affinis *'Cristata'*
Often referred to as the king of British ferns, this handsome cultivar has arching shuttlecocks of semi-evergreen fronds with frilled or crested tips. Surprisingly tolerant, it will withstand some sun and wind exposure. A good container plant.

H: 36 in (90 cm); **S**: 36 in (90 cm)
❄❄❄ ◑ ☼ ☀

Perennials and ornamental grasses

Echinops ritro *'Veitch's Blue'*
Globe thistles are statuesque plants with coarse, deeply-toothed leaves and spherical, macelike flowerheads that are a magnet for bees, butterflies, and moths. This cultivar produces an abundance of steely blue blooms on upright, silvery stems.

H: 4 ft (1.2 m); **S**: 18 in (45 cm)
❄❄❄ ◊ ◑ ☼ ☀

Eryngium *x* oliverianum
One of the most ornamental of the sea hollies, from midsummer this hybrid has branching stems carrying abundant thimblelike heads of metallic blue, each with an elegant spiny "ruff." Although the blooms fade, they persist into fall.

H: 36 in (90 cm); **S**: 18 in (45 cm)
❄❄❄ ◊ ☼

Euphorbia characias *'Humpty Dumpty'*
This compact, evergreen spurge blooms in spring, its chunky, acid-green flowerheads contrasting well with the gray-green foliage. Remove faded flower stems but avoid touching the sap, which may irritate the skin.

H: 24 in (60 cm); **S**: 20 in (50 cm)
❄❄❄ ◊ ☼













Helictotrichon sempervirens
Blue oat grass is evergreen and drought tolerant. In early and mid-summer, the tussocks of narrow, steely blue-gray leaves send up long stems carrying oatlike flowerheads. Use as a specimen in gravel or for massed plantings.

H: 4 ft (1.2 m); **S**: 24 in (60 cm)
❄❄❄ ◊ ☼

Hemerocallis *'Corky'*
A free-flowering daylily that blooms from early to midsummer. Slender stems with dark buds produce a succession of starry yellow blooms with brown stripes on the back of the petals. Clumps of narrow, strap-shaped leaves appear in early spring.

H: 28 in (70 cm); **S**: 16 in (40 cm)
❄❄❄ ◑ ☼ ☀

Iris foetidissima
The stinking iris (its bruised leaves can smell unpleasant) has striking orange berries that burst from large pods in fall and remain attractive for weeks against the glossy, evergreen foliage. An invaluable plant for dry shade. 'Variegata' is white-striped.

H: 36 in (90 cm); **S**: 4 ft (1.2 m)
❄❄❄ ◊ ◑ ☼ ☀

Iris sibirica *'Perry's Blue'*
Early-summer-flowering Siberian iris cultivars produce blooms in shades of blue, purple, and white and give a strongly vertical accent to the border. Their grassy foliage contrasts nicely with broadleaved plants and they have attractive seed pods.

H: 4 ft (1.2 m); **S**: 36 in (90 cm)
❄❄❄ ◑ ● ☼ ◑

Knautia macedonica *Melton pastels*
This pincushion-flowered perennial bears blooms in shades of deep crimson through to pinks and purples. The loose tangle of branched stems creates a natural effect suitable for informal gardens. Deadhead regularly.

H: 4 ft (1.2 m); **S**: 20 in (50 cm)
❄❄❄ ◊ ☼

Kniphofia *'Little Maid'*
An unusual and dainty red-hot poker that forms stiff, grassy clumps from which pale green flower buds appear in late summer and early fall. These expand to form pokers of pale yellow blooms that fade to cream. Protect flower buds from slugs.

H: 24 in (60 cm); **S**: 18 in (45 cm)
❄❄❄ ◊ ☼








Leucanthemum *x* superbum
The ubiquitous Shasta daisy tolerates a range of situations, including heavy clay, and will even hold its own in light grass cover. The long-stemmed white flowers emerge from a clump of leathery, dark green leaves from early summer to early fall.

H: 36 in (90 cm); **S**: 24 in (60 cm)
❄❄❄ ◑ ☼ ◑

Libertia grandiflora
This architectural New Zealander produces handsome, fan-shaped tufts of olive-green leaves. In late spring and early summer, sprays of white flowers appear, followed by brown seed pods, which turn black as they mature. Mulch for winter.

H: 36 in (90 cm); **S**: 24 in (60 cm)
❄❄❄ ◑ ☼

Lilium *'Enchantment'*
An easy, clump-forming lily, this is perfect planted near the front of the border. In early summer, the upright-facing, star-shaped blooms of bold orange open to reveal black-speckled centers. Add compost to sandy soils and watch out for lily beetles.

H: 24 in (60 cm); **S**: 6 in (15 cm)
❄❄❄ ◊ ◑ ☼ ◑

Perennials and ornamental grasses

Miscanthus sinensis *'Kleine Silbespinne'*
This compact ornamental grass with white-ribbed leaves is ideal for small gardens. In late summer, it is crowned with silky tufts of purple-tinged blooms that fade to white in fall and remain attractive into winter.

H: 4 ft (1.2 m); **S**: 36 in (90 cm)
❄❄❄ ◑ ☼ ◑

Miscanthus sinensis *'Variegatus'*
Variegated with creamy-white stripes, this tall grass adds light and stature to the border. For small gardens, choose 'Morning Light', which reaches 4–5 ft (1.2–1.5 m) and has narrower blades with a fine white margin. Both bear red-brown flowers in late fall.

H: 6 ft (1.8 m); **S**: 4 ft (1.2 m)
❄❄❄ ◑ ☼ ◑

Panicum virgatum *'Heavy Metal'*
The prairie switchgrasses are noted for their fall foliage tints and airy panicles. 'Heavy Metal' has upright clumps of metallic, blue-gray foliage, which begin turning yellow in fall. From late summer, plants have a halo of purple-tinged flowers.

H: 36 in (90 cm); **S**: 30 in (75 cm)
❄❄❄ ◑ ☼








Penstemon *'Schoenholzeri'*
Narrow-leaved penstemons, like this free-flowering cultivar, are particularly hardy. These evergreen perennials produce a long succession of flowers from midsummer, especially if deadheaded regularly. Cut back to new leaf growth in spring.

H: 30 in (75 cm); **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼

Penstemon *'Stapleford Gem'*
This pretty, two-tone penstemon has broad leaves and an upright habit. The newer "bird" series has produced several excellent taller cultivars, such as 'Osprey', with pink and white blooms, the striking purple 'Raven', and the reddish-purple 'Blackbird'.

H: 24 in (60 cm); **S**: 18 in (45 cm)
❄❄❄ ◊ ◑ ☼

Perovskia *'Blue Spire'*
Russian sage forms a clump of gray-green, toothed leaves. In late summer, wiry, branched, white stems carry tiny clusters of violet-blue flowers. A good dry garden specimen and bee magnet. The frosty-looking stems are attractive in winter.

H: 4 ft (1.2 m); **S**: 36 in (90 cm)
❄❄❄ ◊ ☼

Phlomis russeliana
This perennial's charm comes from the way the pale yellow flowers are arranged in ball-like clusters along the upright stems. The hooded blooms reach their peak in early summer but continue until early fall. Combine with other drought-tolerant plants.

H: 36 in (90 cm); **S**: 30 in (75 cm)
❄❄❄ ☼

Rudbeckia fulgida *var.* deamii
This black-eyed Susan provides vivid late summer and fall color with its golden, daisylike blooms, each with a dark, raised center. It is happy in heavy soil, and the dried flowers offer winter interest. *R. fulgida* var. *sullivantii* 'Goldsturm' is similar.

H: 24 in (60 cm); **S**: 18 in (45 cm)
❄❄❄ ◑ ☼ ◑

Salvia *x* superba
A hybrid sage, used most effectively in large swaths, which produces upright spires of glowing violet-purple flowers between midsummer and early fall. *S. nemorosa* 'Lubecca' and *S. verticillata* 'Purple Rain' are longer-flowering and more compact.

H: 36 in (90 cm); **S**: 18 in (45 cm)
❄❄❄ ◑ ☼













Sedum *'Matrona'*
This fashionably dark-leaved sedum produces domed heads of tight buds that open to pink blooms in late summer, and form attractive seed-heads in fall. Both foliage and stems are a dusky purple. Divide every 3–4 years. Also try 'Herbstfreude' .

H: 24 in (60 cm); **S**: 24 in (60 cm)
❄❄❄ ☼ ◑

Stipa gigantea
Giant feather grass is an evergreen, tussock-forming species that, in summer, produces tall, arching stems with large, oatlike flowers. These are green at first, turning a glistening golden yellow with age. Excellent as a specimen or mingled with flowers.

H: 8 ft (2.5 m); **S**: 4 ft (1.2 m)
❄❄❄ ☼

Verbena bonariensis
Superb planted *en masse*, this tall-stemmed, elegant, self-seeding plant can be used toward the front of a border or beside paving. The many small, domed heads of violet flowers are produced from midsummer to fall and attract butterflies.

H: 6 ft (1.8 m); **S**: 18 in (45 cm)
❄❄ ☼

Plant pruning guide (Ab–Ca)

Abelia *x* grandiflora
This *Abelia* is grown for its flowers or attractive variegated or gold foliage. In spring, prune out any stems with leaves that have lost their variegation. Usually requires little pruning except for leggy branches, and dead or damaged stems.

H: 10 ft (3 m); **S**: 12 ft (4 m)
❄❄ 💧 ☼

Acer davidii
The snakebark maple is famed for its bark, which provides wonderful winter interest. It is best grown on a single, clear trunk, which is achieved when the plant is small by removing the lower branches in summer or winter with pruning shears.

H: 50 ft (15 m); **S**: 50 ft (15 m)
❄❄❄ ◑ ☼ ◑

Acer palmatum
All cultivars are grown for their lovely foliage and fall colors. Prune leggy branches in midsummer to maintain a good shape. Remove any winter dieback in early spring and dead, diseased, or damaged branches when you see them.

H: 25 ft (8 m); **S**: 30 ft (10 m)
❄❄❄ ◑ ☼ ◑













Actinidia deliciosa
Kiwi fruit is a climber grown for its lovely foliage and fall colors. Prune leggy branches in midsummer to maintain a good shape. Remove any winter dieback in early spring and dead, diseased, or damaged branches when you see them.

H: 30 ft (10 m)
❄❄ 💧 ☼ ◑

Artemisia '*Powis Castle*'
This feathery shrub has attractive silver foliage that is lightly trimmed in spring to maintain its shape and to encourage growth. Give it a light shear as for lavender (*see p.344*), but do not cut back too hard or the plant will not rejuvenate.

H: 24 in (60 cm); **S**: 36 in (90 cm)
❄❄ 💧 ☼

Aucuba japonica
Grown for its glossy evergreen leaves, female plants can also bear attractive red berries, and many cultivars have decoratively spotted or variegated foliage. Prune plants lightly at any time to keep their shape; they also respond well to hard pruning.

H: 10 ft (3 m); **S**: 10 ft (3 m)
❄❄❄ 💧 ◑ ☼ ◑ ●

Berberis *x* stenophylla
Grow this prickly gold-flowering plant as a freestanding shrub or hedge. If it gets too big, prune as for a mahonia (*see p.346*). To keep compact, after flowering remove one-third of the oldest stems and shorten leggy stems. Wear thick gloves.

H: 10 ft (3 m); **S**: 15 ft (5 m)
❄❄❄ ◊ ◑ ☼ ◑

Berberis thunbergii
Compact, with yellow flowers, bright red berries, and great fall color, this berberis has many uses. Wearing thick gloves, lightly prune in late summer or early fall to maintain its shape, or prune like a mahonia (*see p.346*) if it becomes too big.

H: 3 ft (1 m); **S**: 8 ft (2.5 m)
❄❄❄ ◊ ◑ ☼ ◑

Betula utilis *var.* jacquemontii
Grown for its attractive silvery-white bark. Remove the lower branches over several years as it matures. A trunk of 6 ft (2 m) is ideal for showing off the bark. Remove any damaged, diseased, or crossing branches from the canopy in midsummer or winter.

H: 60 ft (18 m); **S**: 30 ft (10 m)
❄❄❄ ◊ ◑ ☼ ◑








Buddleja davidii
The butterfly bush is a vigorous summer-flowering shrub. Prune it in late winter or early spring. Cut the branches back to two buds from the base of last season's growth. After flowering, also remove spent flowers to prevent them from seeding.

H: 10 ft (3 m); **S**: 15 ft (5 m)
❄❄❄ ◊ ◑ ☼ ◑

Buxus sempervirens
Often used as a small, formal hedge, this evergreen can also be trained into topiary shapes. When trained in either way, it is advisable to prune at least twice a year: once in late spring, and then again in midsummer.

H: 15 ft (5 m); **S**: 15 ft (5 m)
❄❄❄ ◊ ◑ ☼ ◑

Calluna vulgaris
Common Scottish heather flowers during the summer months, and some cultivars have lovely golden foliage. For best results, it should be trimmed annually with shears in early spring, but don't cut back into old wood as the plant will not rejuvenate.

H: 4–24 in (10–60 cm); **S**: up to 30 in (75 cm) ❄❄❄ ◊ ☼

Plant pruning guide (Ca–Ch)

Camellia japonica
This evergreen spring-flowering shrub does not require much pruning. To maintain its shape, branches may need trimming back after flowering. If the plant has grown too large, reduce and rejuvenate it by very hard pruning in summer.

H: 28 ft (9 m); **S**: 25 ft (8 m)
❄❄❄ ◑ ☼ ◑



Camellia *x* williamsii '*Donation*'
A spring-flowering evergreen shrub that is grown as a specimen plant or informal hedge. Remove leggy growths after flowering to maintain the plant's health. If it has grown too large, hard-prune to rejuvenate after flowering has finished.

H: 15 ft (5m); **S**: 8 ft (2.5 m)
❄❄❄ ◑ ☼ ◑



Campsis *x* tagliabuana
Train this vigorous exotic-looking climber, which flowers in the summer, up a wall, fence, or other permanent structure. To keep the plant at a manageable size, spur-prune each of the stems back to two pairs of buds in early spring.

H: 30 ft (10 m)
❄❄ ◊ ◑ ☼ ◑





Carpinus betulus
Hornbeam is a deciduous tree that can be used as either a freestanding ornamental plant or hedging. When grown as a tree, minimal pruning is required, but trim a hedge in late summer, or renovate old hedges in late winter).

H: 80 ft (25 m); **S**: 70 ft (20 m)
❄❄❄ ◊ ◑ ☼ ◑



Caryopteris *x* clandonensis '*Arthur Simmonds*'
This lovely small shrub has beautiful blue flowers in late summer and decorative, aromatic silver foliage. Prune it lightly in early spring, as for *Fuchsia magellanica* (*see p.341*).

H: 3 ft (1 m); **S**: 5 ft (1.5 m)
❄❄❄ ◊ ☼



Catalpa bignonioides
When grown as a tree, prune only to remove dead, diseased, and crossing stems. Alternatively, coppice young plants annually, to contain their size and encourage strong growths with extra-large, decorative leaves.

H: 50 ft (15 m); **S**: 50 ft (15 m)
❄❄❄ ◑ ☼

Ceanothus '*Blue Mound*'
This form of the evergreen California lilac flowers in early summer. A light pruning after flowering helps to limit the size of *Ceanothus*, but do not cut back into the old wood as plants don't normally regenerate.

H: 5 ft (1.5 m); **S**: 6 ft (2 m)
❄❄ ◊ ◑ ☼ ◑

Ceratostigma willmottianum
This wonderful little shrub has lovely blue flowers in the late summer. To prune, cut all the previous year's growths down to just above ground level in early to mid-spring. Mulch with garden compost and the plant will erupt into growth.

H: 3 ft (1 m); **S**: 5 ft (1.5 m)
❄❄❄ ◊ ◑ ☼

Cercis canadensis '*Forest Pansy*'
A small tree that is grown for its early summer lilac-pink flowers and purple foliage, which turns vibrant red in the fall. Prune carefully when young to create a good branch structure. Thereafter, prune only if it becomes too large or branches get in the way.

H: 30 ft (10 m); **S**: 30 ft (10 m)
❄❄❄ ◊ ◑ ☼ ◑



Chaenomeles *cultivars*
Grow flowering quinces as free-standing shrubs or train against a wall. Prune after flowering, cutting all new growths back to five or six buds. These will produce spurs covered in flowers the following spring. Also remove long or wayward branches.

H: up to 8 ft (2.5 m); **S**: up to 10 ft (3 m) ❄❄❄ ◊ ☼ ◑

Chimonanthus praecox
A highly scented, winter-flowering shrub whose flowers are produced from stems that are several years old, so prune just the leggy growths after flowering has finished. If it is too large, hard-prune in the winter, but it then will not flower for several years.

H: 12 ft (4 m); **S**: 10 ft (3 m)
❄❄❄ ◊ ☼

Choisya ternata
The Mexican orange blossom is a flowering evergreen shrub. It requires little pruning, aside from removing in spring growths damaged by winter frosts. If the plant is looking untidy, it responds very well to hard pruning almost to ground level in early spring.

H: 8 ft (2.5 m); **S**: 8 ft (2.5 m)
❄❄❄ ◊ ◑ ☼

Plant pruning guide (Cl–Co)

Clematis alpina
Violet-blue flowers appear in spring on last year's growth, followed by attractive fluffy seedheads. To prune, remove dead or damaged growths in early spring. For an overgrown plant, hard-prune to 6 in (15 cm) from the ground in early spring.

H: 6–10 ft (2–3 m), Group 1
❄❄❄ ◊ ◑ ☼ ☼

Clematis armandii
This evergreen clematis has large white, scented flowers. It is not fully hardy and prefers the shelter of a warm, sunny wall or fence. To prune, remove any growths in spring that have died or been damaged by cold winter weather.

H: 10–15 ft (3–5 m), Group 1
❄❄ ◊ ◑ ☼ ☼

Clematis '*Etoile Violette*'
A vigorous clematis that produces masses of purple flowers in late summer on its current year's growth. To prune, cut back all growths to 6–12 in (15–30 cm) above ground level in early spring.

H: 10–15 ft (3–5 m), Group 3
❄❄❄ ◊ ◑ ☼ ☼













Clematis '*H.F. Young*'
This clematis has large blue flowers in early summer. Prune lightly in early spring. From the top, prune each stem to the first pair of healthy buds. If the plant becomes too large, hard prune in early spring to 6 in (15 cm) above ground level.

H: 8 ft (2.5 m), Group 2
❄❄❄ ◊ ◑ ☼ ☼

Clematis '*Jackmanii*'
Producing masses of deep purple-blue flowers in summer on its current year's stems, this old favorite should be pruned in early spring. Cut back all growth to 6–12 in (15–30 cm) above ground level.

H: 10 ft (3 m), Group 3
❄❄❄ ◊ ◑ ☼ ☼

Clematis '*Nelly Moser*'
This popular clematis produces large pink flowers in late spring and again in late summer. Prune lightly in early spring, cutting each stem back to the first pair of healthy buds. Hard prune overgrown plants to 6 in (15 cm) from the ground in early spring.

H: 6–10 ft (2–3 m), Group 2
❄❄❄ ◊ ◑ ☼ ☼

Cornus alba
Dogwood is grown for its lovely winter stem colors and, of the many varieties, *C. alba* is a cheerful red. To encourage strong, colorful stems, prune in spring. If left unpruned, the stems start to lose their winter colors as they age.

H: 10 ft (3 m); **S**: 10 ft (3 m)
❄❄❄ ◊ ◑ ● ☼ ◑

Cornus alternifolia '*Variegata*'
This lovely shrub has white flowers in spring, and variegated leaves cover its tiered branches. To prune, remove lower branches of young plants for a more distinct shape, and occasionally thin the canopies of older trees to emphasize their horizontal structure.

H: 10 ft (3 m); **S**: 8 ft (2.5 m)
❄❄❄ ◊ ◑ ☼ ◑

Cornus kousa *var.* chinensis
The white bracts in late spring, red summer fruits, and fall leaves make this a valuable garden plant. In summer or winter, remove some lower branches on young plants so you can see the ornamental bark, and cut out crossing stems in the canopy.

H: 22 ft (7 m); **S**: 15 ft (5 m)
❄❄❄ ◊ ◑ ☼ ◑








Cornus sanguinea '*Winter Beauty*'
To produce multicolored stems during the winter, prune this plant in late spring to encourage strong growth. When young, it is best not to prune for two years to help it to establish; then prune annually.

H: 10 ft (3 m); **S**: 8 ft (2.5 m)
❄❄❄ ◊ ◑ ● ☼ ◑

Corylus avellana '*Contorta*'
A slow-growing shrub with contorted stems, this hazel looks its best during the winter. In spring and summer, the branches are hidden under a mass of untidy leaves. Prune it only to remove any damaged, diseased, dead, or crossing branches.

H: 15 ft (5 m); **S**: 15 ft (5 m)
❄❄❄ ◊ ◑ ☼ ◑

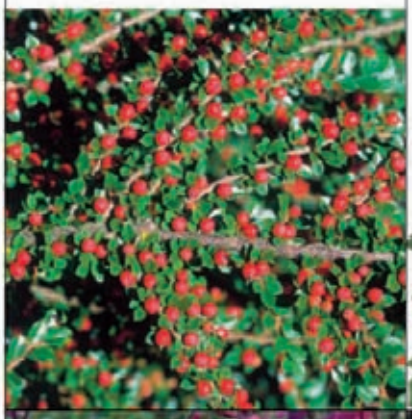
Cotinus coggygria
The smoke bush is grown for its colorful foliage and plumelike flowers. If left unpruned, it can become very large, so trim annually, but you may lose the flowers. For strong growth with larger leaves, hard-prune annually.

H: 15 ft (5 m); **S**: 15 ft (5 m)
❄❄❄ ◊ ◑ ☼ ◑

Plant pruning guide (Co–Eu)

Cotoneaster horizontalis
This low-growing shrub is excellent for covering walls and banks, and it is also suitable as ground cover. *Cotoneaster* has wonderful red berries in the fall. Prune in early spring to retain its shape and to prevent it from spreading too far.

H: 3 ft (1 m); **S**: 5 ft (1.5 m)
❄❄❄ 💧 ◑ ☼ ◑



Crataegus monogyna
The hawthorn is widely grown as an ornamental tree or as a hedging plant. It has scented flowers in late spring and is covered in red berries in fall. No pruning is required for a tree, but trim a hedge in early spring to reduce any wildlife disturbance.

H: 30 ft (10 m); **S**: 25 ft (8 m)
❄❄❄ 💧 ◑ ☼ ◑



Cytisus *x* praecox
This flowering broom is covered with golden yellow flowers in early summer. It requires minimal pruning, but can be given a light trim immediately after flowering to retain its shape. Do not cut back into the old wood as it will not regenerate.

H: 4 ft (1.2 m); **S**: 5 ft (1.5 m)
❄❄❄ 💧 ☼





Daboecia cantabrica *f.* alba
Give summer-flowering members of the heather family a light trim with a pair of shears in early spring. Remove all the old flowers, but don't be tempted to cut into the old wood as this will not regenerate.

H: 10–16 in (25–40 cm); **S**: 26 in (65 cm) ❄❄❄ 💧 ☼ ◑



Daphne bholua
The sweetly scented flowers of this shrub appear in winter. Pinch out the growing tips of young plants to encourage a bushy habit. This can also be done to older specimens, but do not hard-prune as the plant will not respond well.

H: 6–12 ft (2–4 m); **S**: 5 ft (1.5 m)
❄❄ 💧 ☼ ◑



Deutzia *x* hybrida '*Mont Rose*'
This lovely early summer-flowering shrub is easy to grow. Prune after flowering as for *Philadelphus* (*see p.347*), and aim to remove about one-third of the old stems to encourage new growths to push through from the base of the plant.

H: 4 ft (1.2 m); **S**: 4 ft (1.2 m)
❄❄❄ 💧 ◑ ☼ ◑

Elaeagnus pungens '*Maculata*'
This evergreen with gold-splashed foliage is grown as a freestanding shrub or a hedge. Prune in winter or spring by cutting back the previous season's growth to two or three leaf buds. To avoid reversion, cut back all-green leaves to golden foliage.

H: 12 ft (4 m); **S**: 15 ft (5 m)
❄❄❄ ◊ ☼

Erica arborea *var.* alpina
The heather family includes many varieties, and this is one of the larger members. Tree heather produces masses of scented white flowers in the spring. Unlike other heathers, overgrown plants respond very well to hard pruning in mid-spring.

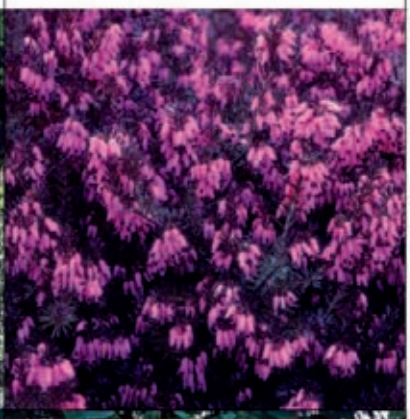
H: 6 ft (2 m); **S**: 34 in (85 cm)
❄❄❄ ◊ ☼

Erica carnea
This pretty winter-flowering member of the heather family should be pruned with shears in mid- to late spring. Remove the flowers, but do not cut into the old wood, as the plant will not regenerate.

H: 8–10 in (20–25 cm); **S**: 22 in (55 cm) ❄❄❄ ◊ ☼













Erica cinerea *f.* alba
The bell heather flowers from mid- to late summer. Trim in early spring using shears to remove the old flower spikes. Don't cut into old wood, as the plant will not regenerate.

H: 12 in (30 cm); **S**: 22 in (55 cm)
❄❄❄ ◊ ☼

Escallonia '*Apple Blossom*'
Grow this evergreen, early-summer-flowering shrub as a hedge or a freestanding plant. From mid- to late summer, cut back flowering shoots by one-half to keep the plant relatively compact. For plants that are too large, hard-prune after flowering.

H: 8 ft (2.5 m); **S**: 8 ft (2.5 m)
❄❄❄ ◊ ◑ ☼

Eucalyptus gunnii
This beautiful plant has distinctive silver-blue foliage. It can be allowed to grow into a large tree, but to keep it as a small bush, hard-prune annually in early spring. The resulting vibrantly colored young foliage also makes an excellent focal point.

H: to 80 ft (25 m); **S**: to 50 ft (15 m)
❄❄ ◊ ◑ ☼

Plant pruning guide (Eu–Ha)

Euonymus europaeus
The spindle tree is grown for its fall colors and interesting fruits. Prune young trees to create a good shape and structure; older trees require little pruning aside from the removal of dead, damaged, or diseased wood and crossing stems.

H: 10 ft (3 m); **S**: 8 ft (2.5 m)
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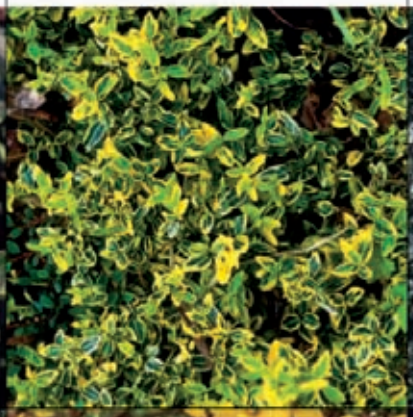
Euonymus fortunei
Train this evergreen foliage plant up a wall or fence, or grow it as ground cover or a freestanding shrub. Lightly trim in early spring to maintain a good shape. Remove immediately any reversion (stems with all-green foliage) on variegated forms.

H: 24 in (60 cm); **S**: indefinite
❄❄❄ 💧 ◑ ☼ ◑

Exochorda *x* macrantha '*The Bride*'
This pretty shrub has masses of white flowers in late spring. To maintain a young, vigorous plant, remove some of the oldest stems in spring. Hard-prune an overgrown plant in spring, but you will lose a year's flowering.

H: 6 ft (2 m); **S**: 10 ft (3 m)
❄❄❄ 💧 ◑ ☼ ◑













***x* Fatshedera lizei**
This evergreen shrub has large, shiny leaves similar in shape to ivy, and is suitable for shady areas. It is an excellent foliage plant and requires very little pruning apart from removing leggy growths. This is best done in the spring.

H: 4–6 ft (1.2–2 m); **S**: 10 ft (3 m)
❄❄ 💧 ◑ ☼ ◑

Forsythia *x* intermedia '*Lynwood Variety*'
The vivid yellow spring flowers of this large shrub appear on the previous season's branches. After flowering, remove annually one in three of the oldest branches. Hard-prune overgrown plants in early spring.

H: 10 ft (3 m); **S**: 10 ft (3 m)
❄❄❄ 💧 ◑ ☼ ◑

Fremontodendron '*California Glory*'
This evergreen shrub is normally grown against a sunny wall. Occasionally, very long growths may need to be reduced in length in early summer. Be careful when pruning as the plant can cause skin irritation.

H: 20 ft (6 m); **S**: 12 ft (4 m)
❄❄ 💧 ☼

Fuchsia magellanica
An elegant summer-flowering plant, this fuchsia is grown as a freestanding shrub or a flowering hedge. In early spring, lightly trim the plant just back into green, healthy stems. After a severe winter, however, prune back to ground level.

H: 10 ft (3 m); **S**: 6–10 ft (2–3 m)
❄❄ 💧 ◑ ☼ ◑

Garrya elliptica '*James Roof*'
A large, slightly tender, evergreen shrub normally grown against a sunny wall for winter protection. It is covered with long, decorative, dangling catkins in winter that provide an exciting feature. Prune annually in early spring to contain its size.

H: 12 ft (4 m); **S**: 12 ft (4 m)
❄❄ 💧 ☼ ◑

Gaultheria mucronata
A dwarf evergreen, suckering shrub, *Gaultheria* is covered with very showy, waxlike fruits during the fall. Minimal pruning is required unless the plant is spreading too much and needs to be contained. This is best done in early spring.

H: 4 ft (1.2 m); **S**: 4 ft (1.2 m)
❄❄❄ ◑ ☼ ◑








Genista aetnensis
The Mount Etna broom is a large, graceful shrub with scented summer flowers. To keep it in shape and encourage flowering growths, prune lightly immediately after flowering. Do not cut back into old wood as the shrub will not regenerate.

H: 25 ft (8 m); **S**: 25 ft (8 m)
❄❄❄ 💧 ☼

Griselinia littoralis
This is an excellent evergreen that can be grown as a specimen shrub or a hedge. Trim hedges in late summer and freestanding shrubs in early spring if they become too large. Remove growths damaged by cold, frosty weather in early spring.

H: 25 ft (8 m); **S**: 15 ft (5 m)
❄❄❄ 💧 ☼

Hamamelis *x* intermedia '*Pallida*'
This is a scented late-winter- or early-spring-flowering shrub. It is suitable for a small garden if growth is kept in check. To do this, spur-prune previous year's growths to two or three buds after flowering (*see pp.172–173*).

H: 12 ft (4 m); **S**: 12 ft (4 m)
❄❄❄ 💧 ◑ ☼ ◑

Plant pruning guide (He–Ja)

Hedera helix
Ivies are very versatile, self-clinging climbers. They will cover walls, fences, and trees, and also make good ground cover. When too large, prune back hard in spring to reduce the size. Trim at any time from late spring to midsummer to keep neat.

H: 30 ft (10 m)

Hydrangea arborescens '*Grandiflora*'
This summer-flowering hydrangea has large, creamy white flowerheads. It flowers on new growth and can be pruned like a perennial plant, cutting back to 2–4 in (5–10 cm) above ground level in early spring.

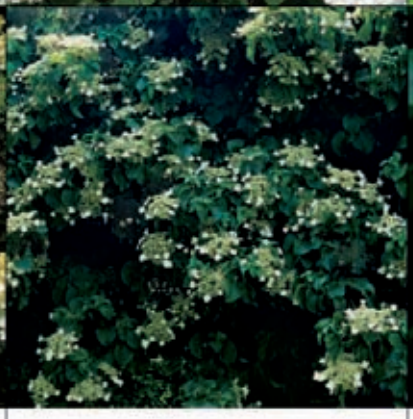
H: 8 ft (2.5 m); **S**: 8 ft (2.5 m)

Hydrangea macrophylla
Florist's hydrangea flowerheads are produced on the previous season's growth. Leave them on the plant over winter to give frost protection. In mid-spring, cut back last year's growth to a pair of healthy buds and remove weak or dead shoots.

H: 6 ft (2 m); **S**: 8 ft (2.5 m)








Hydrangea paniculata
These hydrangeas produce large cone-shaped flowerheads on the current season's growth. To keep them small, prune all the previous season's stems back in early spring to two or three pairs of buds, to leave a low structure of stems.

H: 10–22 ft (3–7 m); **S**: 8 ft (2.5 m)

Hydrangea petiolaris
This self-clinging, climbing hydrangea requires little pruning. Remove growths that are too long in early spring, and old flowerheads after flowering. If the plant is too vigorous, prune hard in early spring, but it may then not flower for up to two years.

H: 50 ft (15 m)

Hypericum '*Hidcote*'
To keep this plant compact and producing masses of yellow summer flowers, remove dead or diseased wood in early spring and prune the remaining stems to 2–4 in (5–10 cm) from the ground. Also cut out one-third of older stems on large shrubs.

H: 4 ft (1.2 m); **S**: 5 ft (1.5 m)

Ilex aquifolium '*Pyramidalis Aureomarginata*'
This holly makes a bold, freestanding tree. It can also be trained into a formal shape or used as a hedge. Prune in early spring (all hollies tolerate severe pruning) and remove all-green foliage on sight.

H: 20 ft (6 m); **S**: 15 ft (5 m)
❄❄❄ ◊ ◑ ☼ ☼

Ilex crenata
Box-leaved holly has small leaves and glossy black berries and makes an excellent clipped hedge or topiary plant. It is a suitable alternative to a boxwood hedge (*Buxus*) and is trimmed in the same way (*see p.169*).

H: 15 ft (5 m); **S**: 12 ft (4 m)
❄❄❄ ◊ ◑ ☼ ☼

Indigofera heterantha
This flowering shrub is covered with masses of pink, pealike flowers during the summer. Hard-prune large plants in early spring. In severe winters, it may suffer from dieback, but if hard-pruned, it will produce a mass of shoots from low down.

H: 6–10 ft (2–3 m); **S**: 6–10 ft (2–3 m) ❄❄❄ ◊ ◑ ☼













Itea ilicifolia
This evergreen shrub has masses of fingerlike stems of green flowers in the summer. It can be grown as a freestanding shrub or against a wall. When young, prune and pinch the plant to shape it in early spring. When older, just trim long growths.

H: 10–15 ft (3–5 m); **S**: 10 ft (3 m)
❄❄ ◊ ◑ ☼

Jasminum nudiflorum
The winter jasmine produces bright yellow flowers over a long period throughout winter and early spring. It is normally trained against a wall or fence. Prune long, leggy growths immediately after it has finished flowering in early spring.

H: 10 ft (3 m); **S**: 10 ft (3 m)
❄❄❄ ◊ ◑ ☼ ☼

Jasminum officinale
Common jasmine has white, scented flowers in the summer. It is a vigorous climber and can be trained up walls or over other structures. Trim at any time to keep the plant within bounds. Hard-prune plants that have grown too large in early spring.

H: 40 ft (12 m)
❄❄ ◊ ◑ ☼ ☼

Plant pruning guide (Ke–Lu)

Kerria japonica '*Golden Guinea*'
A clump-forming suckering shrub covered with large, golden flowers in late spring, *Kerria* can soon outgrow its situation. To contain its size, prune it hard or thin out old stems after flowering each year.

H: 6 ft (2 m); **S**: 8 ft (2.5 m)
❄❄❄ ◊ ◑ ☼ ☼

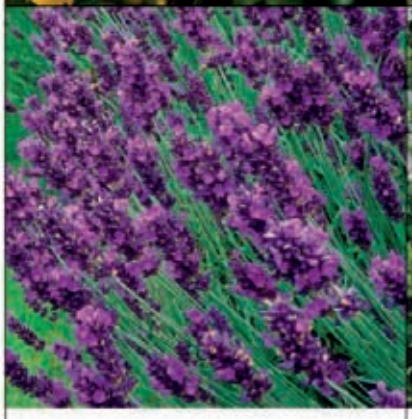
Kolkwitzia amabilis '*Pink Cloud*'
The beauty bush is a large shrub with pendulous branches covered in pink flowers in late spring. Prune it after flowering, removing about one-third of the old flowering stems. Cut back large plants in early spring to 12 in (30 cm) above the ground.

H: 10 ft (3 m); **S**: 12 ft (4 m)
❄❄❄ ◊ ◑ ☼

Laurus nobilis
Bay laurel is an evergreen shrub that can be trained into many formal shapes and makes an excellent topiary specimen. Prune formal and topiary plants during early summer, but use pruning shears to shape them.

H: 40 ft (12 m); **S**: 30 ft (10 m)
❄❄ ◊ ◑ ☼ ☼





Lavandula angustifolia
This lavender is a mass of blue-purple aromatic flowers during the summer. It makes an excellent low-growing hedge. For best results, prune twice a year: shear back in early spring and then trim lightly once it has finished flowering.

H: 3 ft (1 m); **S**: 4 ft (1.2 m)
❄❄❄ ◊ ☼

Lavatera x clementii '*Barnsley*'
Mallow is a shrubby perennial that produces an abundance of large, pale pink summer flowers. To keep a plant young and healthy, prune in spring to a framework of strong stems about 12 in (30 cm) high. Also remove any dead, diseased, or weak branches.

H: 6 ft (2 m); **S**: 6 ft (2 m)
❄❄❄ ◊ ☼

Lespedeza thunbergii
A lovely late summer-flowering shrubby perennial, bush clover has arching stems covered in deep pink, pealike flowers. Prune back all the stems in spring to just above ground level and new young shoots will quickly appear.

H: 6 ft (2 m); **S**: 10 ft (3 m)
❄❄❄ ◊ ☼

Leycesteria formosa
This shrub has white flowers surrounded by maroon bracts during the summer, followed by purple berries. It is almost indestructible and can be left unpruned, or it grows just as well if it is hard-pruned every year in early spring.

H: 6 ft (2 m); **S**: 6 ft (2 m)
❄❄❄ 💧 ◑ ☼ ◑

Ligustrum lucidum
The panicles of white flowers on this evergreen shrub appear during late summer. It has a lovely, even shape and requires minimal pruning. Occasionally, it may be necessary to trim a few of the branches to maintain its shape.

H: 30 ft (10 m); **S**: 30 ft (10 m)
❄❄❄ 💧 ☼ ◑

Lonicera nitida
This form of evergreen honeysuckle is often used as a hedging plant or a shrub. When grown as a hedge, trim it several times in the summer to maintain its shape. For a free-standing shrub, remove about a third of the older stems in early spring.

H: 11 ft (3.5 m); **S**: 10 ft (3 m)
❄❄❄ 💧 ◑ ☼ ◑













Lonicera periclymenum '*Graham Thomas*'
If it's a highly scented summer-flowering climber that you are after, this is the plant for you. If it becomes straggly, prune in early spring. Also remove any dead or damaged wood at this time.

H: 22 ft (7 m)
❄❄❄ 💧 ◑ ☼ ◑

Lonicera *x* purpusii
This shrubby honeysuckle is grown for its creamy white, highly scented winter flowers. To keep the plant to a manageable size, remove one-third of the old stems to almost ground level in early spring.

H: 6 ft (2 m); **S**: 8 ft (2.5 m)
❄❄❄ 💧 ☼ ◑

Luma apiculata
An evergreen shrub or small tree grown for its attractive peeling bark and small white flowers, which appear in late summer. As it grows, remove some of the lower branches in the summer so that you can fully appreciate the wonderful bark.

H: 30–50 ft (10–15 m); **S**: 30–50 ft (10–15 m) ❄❄ 💧 ☼ ◑

Plant pruning guide (Ma–Ph)

Magnolia grandiflora
Grow this lovely evergreen, summer-flowering tree against a south-facing wall, and prune in the spring or summer to maintain its shape. Pruning reduces the chance of die-back and allows the wounds to heal before the cold winter months set in.

H: 20–60 ft (6–18 m); **S**: 50 ft (15 m)



Magnolia x loebneri '*Leonard Messel*'
This spring-flowering tree requires minimal pruning. When it is young, you may need to remove a few lower branches in the spring or summer to give it a good shape. As it gets older, cut back any obstructive branches.

H: 25 ft (8 m); **S**: 20 ft (6 m)



Mahonia aquifolium
An evergreen suckering shrub that flowers in the winter and makes good ground cover. To keep Oregon grape at a reasonable size, cut it down to ground level every three or four years after flowering, or remove one-third of the oldest stems every year.

H: 3 ft (1 m); **S**: 3 ft (1 m)





Mahonia x media '*Charity*'
If this evergreen, winter-flowering shrub has outgrown its site, hard-prune in early spring. To keep it in good shape, shorten leggy growths in early spring and remove flowering shoots to encourage growth from lower down.

H: to 15 ft (5 m); **S**: to 12 ft (4 m)



Malus '*Golden Hornet*'
When this flowering and fruiting ornamental crab apple is young, remove lower branches in winter to encourage a good shape. On an older tree, remove dead or diseased wood immediately, and cut off any branches causing an obstruction.

H: 30 ft (10 m); **S**: 25 ft (8 m)



Malus hupehensis
This is an ornamental flowering and fruiting apple tree. When it is young, remove lower branches in winter to encourage a good shape. Remove dead or diseased branches on old plants at any time, and cut off any others that are out of place.

H: 40 ft (12 m); **S**: 40 ft (12 m)

Nandina domestica
This evergreen, clump-forming shrub has white flowers during the summer followed by berries in the fall. It requires minimal pruning to maintain its shape—remove the oldest stems in the summer. Over-pruning reduces the number of flowers produced.

H: 6 ft (2 m); **S**: 5 ft (1.5 m)
❄❄ ◊ ◑ ☼

Olearia stellulata
The daisy bush is a compact, free-flowering evergreen shrub that is covered in white flowers in late spring. Hard-prune leggy, untidy specimens immediately after flowering has finished.

H: 6 ft (2 m); **S**: 6 ft (2 m)
❄❄ ◊ ☼

Osmanthus heterophyllus '*Variegatus*'
An evergreen compact shrub with small, fragrant white flowers and hollylike leaves, used for hedging or topiary. Prune hedges in late spring or early summer, and clip topiary in the summer.

H: 15 ft (5 m); **S**: 15 ft (5 m)
❄❄ ◊ ☼ ◑








Parthenocissus tricuspidata
Boston ivy is a vigorous, self-clinging climber that is grown for its attractive fall foliage colors, which range from brilliant red to purple. Prune in spring before it comes into leaf or in fall after leaf drop to maintain its shape and keep it in check.

H: 70 ft (20 m)
❄❄❄ ◊ ◑ ☼ ◑

Perovskia '*Blue Spire*'
This is an attractive compact shrub with blue flowers in the late summer and attractive silvery foliage. Prune annually in spring, cutting back the stems to 6 in (15 cm) to encourage strong growths, which will flower during the forthcoming summer.

H: 4 ft (1.2 m); **S**: 3 ft (1 m)
❄❄❄ ◊ ☼

Philadelphus
Mock orange is grown for its white, highly scented flowers, which appear in early summer. Hard-prune the shrub to 6 in (15 cm) in early spring every three or four years, or remove one-third of the oldest stems annually after flowering.

H: to 10 ft (3 m); **S**: to 8ft (2.5m)
❄❄❄ ◊ ◑ ☼ ◑

Plant pruning guide (Ph–Rh)

Photinia *x* fraseri '*Red Robin*'
An evergreen shrub that has attractive bright red new growths and can be grown as a freestanding shrub or decorative hedge. If grown as a hedge, trim in late summer; a freestanding plant should be shaped in early spring.

H: 15 ft (5 m); **S**: 15 ft (5 m)
❄❄❄ ◊ ◑ ☼ ◑

Phygelius *x* rectus '*African Queen*'
This plant has long, tubular, orange flowers during the summer. To prevent the plant from becoming leggy, treat it like a perennial, cutting back all the stems to almost ground level in the spring.

H: 5 ft (1.5 m); **S**: 5 ft (1.5 m)
❄❄ ◊ ◑ ☼

Physocarpus opulifolius '*Dart's Gold*'
An attractive clump-forming shrub with bright yellow new foliage, it produces white flowers in early summer. Little pruning is required, except to remove any of the outer stems that are spoiling its shape.

H: 6 ft (2 m); **S**: 8 ft (2.5 m)
❄❄❄ ◊ ◑ ☼ ◑








Pittosporum tenuifolium
Many of the forms of this evergreen shrub have variegated foliage and it makes an attractive formal focal point. The only pruning required is to retain the plant's symmetry by lightly trimming it in late spring.

H: 12–30 ft (4–10 m); **S**: 6–15 ft (2–5 m) ❄❄ ◊ ◑ ☼ ◑

Potentilla fruticosa '*Goldfinger*'
An attractive small shrub with golden flowers during the summer, this pretty shrubby potentilla requires just a light trim in early spring to maintain its rounded shape.

H: 3 ft (1 m); **S**: 5 ft (1.5 m)
❄❄❄ ◊ ☼

Prunus avium '*Plena*'
This ornamental cherry has large white flowers in mid-spring. Prune in early summer to reduce the risk of infection. Remove dead, diseased, or crossing branches. Young trees should be pruned at the same time.

H: 40 ft (12 m); **S**: 40 ft (12 m)
❄❄❄ ◊ ◑ ☼

Prunus laurocerasus
Cherry laurel is an evergreen with glossy green leaves. Prune freestanding shrubs in early spring to reduce their size, and a hedge in early fall. Use pruning shears to avoid shredding the leaves. Prune overgrown plants to just above the ground in spring.

H: 25 ft (8 m); **S**: 30 ft (10 m)
❄❄❄ 💧 ◑ ☼ ☀

Prunus mume
This attractive, early flowering ornamental cherry blossoms on last year's shoots. In early summer, reduce the length of all main branches by 12 in (30 cm) to encourage new growths, which will be covered in flowers the following spring.

H: 28 ft (9 m); **S**: 28 ft (9 m)
❄❄❄ 💧 ◑ ☼

Prunus serrula
The attractive mahogany-red bark on this ornamental cherry makes an eye-catching feature in winter. In early summer, remove the lower branches of a young tree to give at least 6 ft (1.8 m) of clear trunk. Remove dead and diseased branches as seen.

H: 30 ft (10 m); **S**: 30 ft (10 m)
❄❄❄ 💧 ◑ ☼








Pyracantha '*Orange Glow*'
Firethorn is an evergreen shrub or small tree grown for its orange fall and winter fruits. It can be grown against a wall, as a hedge, or as a freestanding shrub. Prune in spring to maintain its shape, taking care not to remove flower buds.

H: 10 ft (3 m); **S**: 10 ft (3 m)
❄❄❄ 💧 ☼ ◑ ☀

Pyrus salicifolia *var.* orientalis '*Pendula*'
This attractive silver-leaved weeping pear has creamy-white flowers and small brown, inedible fruits. Remove the lower branches of a young tree in winter to create a clear stem for the weeping branches to cascade down.

H: 15 ft (5 m); **S**: 12 ft (4 m)
❄❄❄ 💧 ☼

Rhamnus alaternus '*Argenteovariegata*'
Prune this fast-growing evergreen shrub in early spring to remove any leggy growths and to maintain the shape of the bush. If any stems with all-green leaves appear, remove them without delay.

H: 15 ft (5 m); **S**: 12 ft (4 m)
❄❄ 💧 ☼

Plant pruning guide (Rh–Ro)

Rhamnus frangula (*syn.* Frangula alnus '*Aspleniifolia*')
In the fall, alder buckthorn has attractive yellow foliage and ornamental berries. The shrub responds well to being hard-pruned to almost ground level every three or four years.

H: 10–12 ft (3–4 m); **S**: 6–10 ft (2–3 m) ❄❄❄ ◑ ☼ ◑

Rhododendron luteum
This deciduous, clump-forming azalea is grown for its attractive yellow, scented flowers in early summer and its fall foliage color. It normally requires very little pruning, but you can hard-prune overgrown plants to almost ground level in early spring.

H: 12 ft (4 m); **S**: 12 ft (4 m) ❄❄❄ ◑ ☼ ◑

Rhododendron *Nobleanum Group*
Most hybrid rhododendrons require little or no pruning, although plants that have rough bark, such as those in the Nobleanum Group, can be pruned in early spring if they are too large. They will regenerate.

H: 15 ft (5 m); **S**: 15 ft (5 m) ❄❄❄ ◑ ☼ ◑













Rhododendron '*Rose Bud*'
This attractive evergreen azalea normally requires very little pruning. However, it can be trained into formal shapes and also makes an attractive, low-growing hedge. In early summer, after flowering has finished, lightly trim with shears.

H: to 36 in (90 cm); **S**: to 36 in (90 cm) ❄❄❄ ◑ ☼

Rhus typhina
A deciduous shrub or small tree, the staghorn sumac has attractive divided foliage, which turns a brilliant orange-red in the fall. Hard-prune it in early spring to keep compact: cut the stems back to between 12–24 in (30–60 cm) from the ground.

H: 15 ft (5 m) or more; **S**: 20 ft (6 m) ❄❄❄ ◑ ☼

Ribes sanguineum '*Pulborough Scarlet*'
The stems of this ornamental currant bear masses of dark red, white-centered flowers in spring. To contain the plant's size and vigor, remove one-third of the oldest stems annually immediately after flowering.

H: 10 ft (3 m); **S**: 8 ft (2.5 m) ❄❄❄ ◑ ☼ ◑

Ribes speciosum
This currant is normally grown and trained against a wall or fence, and has beautiful red flowers from mid- to late spring. Remove one-third of the older stems immediately after flowering and tie the remaining stems to the wall or support.

H: 6 ft (2 m); **S**: 6 ft (2 m)
❄❄❄ ◊ ◑ ☼ ☀

Robinia pseudoacacia '*Frisia*'
The main feature of this deciduous tree is its golden foliage. To produce a small golden shrub, coppice young plants every spring (*see pp.158–159*). Do not prune large trees except to remove dead or diseased wood as the wounds heal slowly.

H: 50 ft (15 m); **S**: 25 ft (8 m)
❄❄❄ ◊ ◑ ☼

Rosa *Baby Love*
This patio rose is grown for its single, clear yellow summer flowers. Prune in early spring, cutting the stems back by one-half to encourage flowering growths (*see pp.186–187*). Also remove any dead or diseased stems and crossing growths.

H: 3½ ft (1.2 m); **S**: 30 in (75 cm)
❄❄❄ ◊ ◑ ☼













Rosa '*Climbing Iceberg*'
Prune climbing roses in fall or early spring. Remove the oldest stems and spur-prune the previous season's flowering growths to two or three buds to encourage more flowers in early summer (*see also pp.214–215*). Tie in any strong new stems.

H: 10 ft (3 m)
❄❄❄ ◊ ◑ ☼

Rosa '*Crimson Shower*'
Grow this rambling rose for its rich red flowers. If trained on a support, remove some of the oldest canes in early spring and spur-prune (*see pp.172–173*). When trained through a tree, you only need to cut out dead or diseased growth.

H: 8 ft (2.5 m); **S**: 7 ft (2.2 m)
❄❄❄ ◊ ◑ ☼

Rosa '*Félicité Parmentier*'
This is a lovely scented, old-fashioned shrub rose. Prune in early spring, reducing the height of the plant by cutting back the main stems by one-quarter, and lightly trimming the side-shoots (*see pp.188–189*). Remove any dead, diseased, and crossing stems.

H: 4½ ft (1.3 m); **S**: 4 ft (1.2 m)
❄❄❄ ◊ ◑ ☼

Plant pruning guide (Ro–Sa)

Rosa glauca
This rose is mainly grown for its attractive blue-green foliage. To keep it tidy and to encourage strong young growths, prune in early spring by removing one-third of the older stems. Hard-prune overgrown plants to about 6 in (15 cm) from ground level.

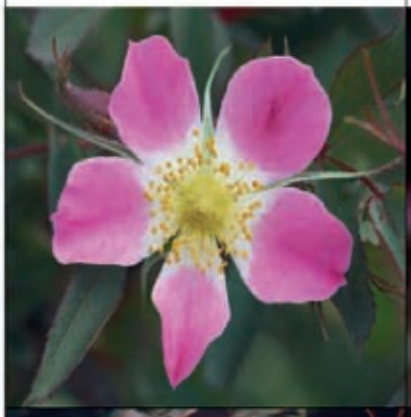
H: 6 ft (2 m); **S**: 5 ft (1.5 m)
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Rosa *Lovely Lady*
A hybrid tea rose with salmon-pink scented flowers, Lovely Lady is pruned in early spring like other hybrid tea roses. Remove all but three or four older growths, and cut these back to about 6 in (15 cm), ideally to an outward-facing bud.

H: 30 in (75 cm); **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼

Rosa mulliganii
Covered with white, scented flowers in the summer and red hips in the fall, this rose will climb up supports or into trees. Remove the oldest canes in early spring and spur-prune lateral growths to three buds to encourage flowers.

H: 20 ft (6 m)
❄❄❄ ◊ ◑ ☼








Rosa *Paul Shirville*
The dark reddish-green foliage of this hybrid tea rose contrasts beautifully with its fragrant rose-pink flowers, which appear from summer to fall. Prune as for Lovely Lady (*above*).

H: 3 ft (1 m); **S**: 30 in (75 cm)
❄❄❄ ◊ ◑ ☼

Rosa *Queen Elizabeth*
Queen Elizabeth is a pink-flowered floribunda rose that blooms from summer to fall. Prune in early spring, leaving 6 or 8 strong stems. Cut these back to about 8–12 in (20–30 cm) from the ground, to an outward-facing bud if possible.

H: 7 ft (2.2 m); **S**: 3 ft (1 m)
❄❄❄ ◊ ◑ ☼

Rosa *Queen Mother*
Prune this floriferous, pale-pink-flowered patio rose in early spring. Prune all the stems back by about one-half to encourage lots of flowering growths. Also remove dead or diseased stems, and any crossing growths.

H: 16 in (40 cm); **S**: 24 in (60 cm)
❄❄❄ ◊ ◑ ☼

Rosa rugosa
This species rose has thorny stems and red, richly perfumed flowers from summer to fall. It makes an effective hedging plant and requires minimal pruning aside from removing one or two of the oldest stems each year in late winter or early spring.

H: 3–8 ft (1–2.5 m); **S**: 3–8 ft (1–2.5 m) ❄❄❄ ◊ ◑ ☼

Rosa '*Sally Holmes*'
"Sally Holmes" is a modern shrub rose that flowers from summer to fall and needs to be pruned in early spring. Reduce its height by one-quarter and remove any dead, diseased, or crossing stems and any weak, twiggy growths.

H: 6 ft (2 m); **S**: 3 ft (1 m) ❄❄❄ ◊ ◑ ☼

Rosa *Trumpeter*
Like Queen Elizabeth (*facing page*), this rose is a floribunda. It is appreciated for its clusters of vivid orange-red flowers that brighten up beds and borders from summer to fall. Prune as for Queen Elizabeth.

H: 24 in (60 cm); **S**: 20 in (50 cm) ❄❄❄ ◊ ◑ ☼













Rosmarinus officinalis
This aromatic herb has small, silvery evergreen leaves and blue flowers in late spring. Old plants do not respond well to hard pruning and are best replaced. Shear young plants in early summer after the flowers have faded to maintain an even shape.

H: 5 ft (1.5 m); **S**: 5 ft (1.5 m) ❄❄ ◊ ◑ ☼

Rubus cockburnianus
Grow this thorny decorative bramble for its winter interest, when the stems are covered in brilliant white bloom. Prune to almost ground level annually in early spring to encourage strong growths. Take care when cutting this shrub because the thorns are vicious.

H: 8 ft (2.5 m); **S**: 8 ft (2.5 m) ❄❄❄ ◊ ☼

Salix alba *var.* vitellina '*Britzensis*'
The orange-yellow stems make this form of white willow a must for winter interest. Coppice or pollard all shoots, first removing weak, dead, or diseased growth, to two or three pairs of healthy buds.

H: 80 ft (25 m) if unpruned; **S**: 30 ft (10 m) ❄❄❄ ◊ ◑ ● ☼

Plant pruning guide (Sa–Sy)

Salix daphnoides
Violet willow is grown for winter interest when the stems are covered in white blooms. Gray catkins follow. Prune hard in spring, cutting strong branches back to two or three pairs of buds from the ground. Remove all weak, dead, or diseased stems.

H: 25 ft (8 m); **S**: 20 ft (6 m)
❄❄❄ 💧 ◑ ☼



Sambucus nigra '*Aurea*'
This ornamental elder is grown for its white flowers, ornamental fruit, and golden yellow leaves. Prune annually in early spring—cut back all its stems to two or three buds of the previous year's growth, to leave a structure similar to *Cotinus* (*see p.337*).

H: 20 ft (6 m); **S**: 20 ft (6 m)
❄❄❄ 💧 ◑ ☼ ◑



Santolina chaemaecyparissus
Aromatic gray foliage and bright yellow pompon flowers in the summer define this shrub. It can be grown as a low hedge or edging plant and also on its own. Trim over in spring using shears in a similar fashion to lavender (*see p.344*).

H: 20 in (50 cm); **S**: 3 ft (1 m)
❄❄ 💧 ☼





Schizophragma hydrangeoides
This vigorous, self-clinging climber produces fragrant, creamy-white, flat-topped flowerheads in midsummer, which are set off by the dark green leaves. Its pruning requirements are the same as for *Hydrangea petiolaris* (*see p.342*).

H: 40 ft (12 m)
❄❄❄ 💧 ◑ ☼ ◑



Skimmia japonica '*Nymans*'
A useful evergreen shrub with scented flowers that appear in mid- to late spring followed by red berries. It requires minimal pruning aside from occasionally shortening some shoots to maintain its shape.

H: 20 ft (6 m); **S**: 20 ft (6 m)
❄❄❄ 💧 ◑ ◑ ●



Solanum crispum '*Glasnevin*'
The Chilean potato tree is a vigorous, slightly tender climber grown for its scented, purple-blue summer flowers. It requires minimal pruning, but can be cut back in spring if it has outgrown its location.

H: 20 ft (6 m)
❄❄ 💧 ◑ ☼

Sorbus commixta
A small, upright tree grown for its fall foliage color and red berries. Sorbus trees require little pruning aside from shaping young specimens in early summer. Remove any dead or diseased branches as soon as you see them.

H: 30 ft (10 m); **S**: 22 ft (7 m)
❄❄❄ ◊ ◑ ☼ ☀

Spiraea japonica
This is a small, deciduous clump-forming shrub with pink or white flowers that appear from mid- to late summer. It flowers on the current year's growth, so hard-prune in early spring if required.

H: 6 ft (2 m); **S**: 5 ft (1.5 m)
❄❄❄ ◊ ◑ ☼

Spiraea nipponica '*Snowmound*'
A fast-growing shrub, with white midsummer flowers that appear on shoots formed the previous year. To encourage these shoots, cut back one-third of the older stems to the base of the plant immediately after flowering.

H: to 8 ft (2.5 m); **S**: to 8 ft (2.5 m)
❄❄❄ ◊ ◑ ☼













Stachyurus '*Magpie*'
A variegated shrub that produces pendulous stems of creamy yellow flowers in spring. It can be grown on its own or against a wall. Freestanding plants require no pruning, while those grown as wall shrubs can be pruned to shape after flowering.

H: 3–12 ft (1–4 m); **S**: 10 ft (3 m)
❄❄❄ ◊ ◑ ☼ ☀

Stewartia pseudocamellia
White flowers in summer and good fall foliage color distinguish this tree. It also has ornamental bark, which can be enjoyed by removing young lower branches in early spring to achieve a clear stem of up to 6 ft (1.8 m). No other pruning is required.

H: 70 ft (20 m); **S**: 25 ft (8 m)
❄❄❄ ◑ ☼ ☀

Syringa vulgaris
Lilac trees offer richly scented flowers from late spring to early summer. They grow without pruning, but if plants need containing, they tolerate being cut back hard every year after flowering, when some of the oldest growths can be removed.

H: 22 ft (7 m); **S**: 22 ft (7 m)
❄❄❄ ◊ ◑ ☼

Plant pruning guide (Ta–Wi)

Tamarix parviflora
Tamarisk is a delightful small tree with fine green foliage and masses of small pink flowers in late spring. As the plant ages, it becomes messy and needs pruning to maintain its shape. It flowers on the previous year's growth, so prune after flowering.

H: 15 ft (5 m); **S**: 20 ft (6 m)
❄❄❄ 💧 ◑ ☼

Tamarix ramosissima '*Pink Cascade*'
This form of tamarisk has fine green foliage and masses of rich, pink, airy flowers, which form on new shoots from late summer to early fall. Prune in early spring, cutting back stems to maintain its shape.

H: 15 ft (5 m); **S**: 15 ft (5 m)
❄❄❄ 💧 ◑ ☼

Taxus baccata
Yew is an evergreen conifer that can be used as a hedging plant or topiary specimen, or trained into formal shapes. Prune yew hedges in late summer, and trim topiary and formal-shaped specimens in summer.

H: to 70 ft (20 m); **S**: to 30 ft (10 m)
❄❄❄ 💧 ☼ ◑ ●








Tilia cordata '*Winter Orange*'
This linden tree has bright yellow foliage in the fall. It can ultimately become a large tree, but with careful training it is ideal for pleaching. Prune to shape in the winter.

H: 90 ft (25 m); **S**: 50 ft (15 m)
❄❄❄ 💧 ◑ ☼ ◑

Toona sinensis '*Flamingo*'
A clump-forming tree grown for its bright pink new foliage, *Toona* also has white flowers in late summer and attractive fall tints. Remove any frost-damaged growths in late spring, and hard-prune large plants in spring, cutting back to almost ground level.

H: 50 ft (15 m); **S**: 30 ft (10 m)
❄❄❄ 💧 ☼

Trachelospermum jasminoides
An evergreen climber with sweetly scented white flowers during the summer, star jasmine prefers to grow against a sheltered wall. No routine annual pruning is required, but you can reduce its height by pruning in late spring.

H: 28 ft (9 m)
❄❄ 💧 ☼ ◑

Viburnum *x* bodnantense '*Dawn*'
Grown for it scented pink flowers that are produced during the fall and early winter, this shrub can be left unpruned to become a large plant or kept small in size by removing one-fifth of the oldest stems to ground level in early spring.

H: 10 ft (3 m); **S**: 6 ft (2 m)
❄❄❄ ◊ ◑ ☼ ◑

Viburnum tinus '*Eve Price*'
This evergreen shrub is grown for its white flowers, which are produced from fall to early spring. It does not require routine annual pruning, but remove damaged or diseased growths when seen. Hard-prune overgrown plants in early spring.

H: 10 ft (3 m); **S**: 10 ft (3 m)
❄❄❄ ◊ ◑ ☼ ◑

Vitex agnus-castus *var.* latifolia
The chaste tree is a deciduous shrub with attractively divided foliage that sets off the spikes of lilac- to dark blue late summer flowers. Prune the previous year's growths back to two or three buds in early spring.

H: 6–25 ft (2–8 m); **S**: 6–25 ft (2–8 m) ❄❄ ◊ ☼













Vitis vinifera '*Purpurea*'
In fall or early winter, cut back this vigorous climbing grape. Spur-prune all side stems to two buds from the previous season's growth to leave short, stubby growths on either side of the main stem. Shorten overly long stems in summer.

H: 22 ft (7 m)
❄❄❄ ◊ ◑ ☼

Weigela florida
A deciduous shrub grown for its tubular dark pink flowers that appear mainly from late spring to early summer. To prune, thin out and remove one-third of the oldest growths immediately after flowering in the summer.

H: 8 ft (2.5 m); **S**: 8 ft (2.5 m)
❄❄❄ ◊ ☼ ◑

Wisteria sinensis
Wisteria is a vigorous climber that produces long, scented chains of flowers in late spring. In the winter, spur-prune all the summer's growth back to two buds. During the summer, shorten long, leggy stems by up to two-thirds.

H: 28 ft (9 m) or more
❄❄❄ ◊ ◑ ☼ ◑

Pruning calendar: spring

Trees to prune

Evergreens, such as *Magnolia grandiflora* and holly (*Ilex*), prefer to be pruned at this time of year, but most other trees are best pruned in summer or winter. In particular, avoid pruning trees that bleed sap profusely, such as birch (*Betula*) and walnut (*Juglans*), from mid-spring onward.

Shrubs to prune

Prune winter-flowering shrubby honeysuckles, such as *Lonicera fragrantissima* and *Lonicera standishii*. In mid-spring, cut back heather (*Erica*), *Buddleja davidii*, early-flowering *Camellia*, witch hazel (*Hamamelis*), *Mahonia*, winter-flowering viburnum (*Viburnum* x *burkwoodii*), dogwood (*Cornus*), willow (*Salix*), and *Rubus*. In late spring, prune hydrangeas and, after flowering, forsythia.

Climbers to prune

Prune clematis in Groups 2 and 3 in the spring, plus any long, wayward stems of climbing hydrangeas (*Hydrangea petiolaris*), and any climbing or rambling roses you missed in fall. Also trim climbing honeysuckles (*Lonicera*), *Jasminum nudiflorum*, and overgrown ivy (*Hedera*).

Hedge care

In late winter or early spring, renovate hornbeam (*Carpinus*), beech (*Fagus*), yew (*Taxus*), and holly (*Ilex*) hedges, and prune wildlife hedges before birds begin to nest. Pruning the latter also ensures that plants develop plenty of flowering shoots and, later, fall berries for wildlife. Prune lavender (*Lavandula*) in mid-spring.



Prune mahonias after flowering.



Renovate hornbeam and beech hedges in early spring.

Main pruning tasks

Spring is a busy time for pruning jobs. The sap is rising and buds are swelling, which means that plants are more likely to recover from a haircut.

The main pruning tasks in the spring are cutting back shrubs with winter stem interest, such as dogwood (*Cornus*), willow (*Salix*), and decorative bramble (*Rubus*).

Follow this by pruning floribunda, hybrid tea, and shrub roses. You can also still prune climbing and rambler roses now if you didn't have time in the fall.

As there are no leaves on most deciduous trees and shrubs at this time of year, you can clearly see and cut out wood damaged in winter by the cold and windy weather.

Other jobs to do now

In spring, tie in the new, flexible stems of climbers. When pruning, you will have removed a lot of the old twining growths that helped the plants hold on to their supports, so they will now need extra help until the new stems have become more established.

Climbing and rambling roses, in particular, don't have a natural twining habit, so they definitely need to be tied in. Likewise, clematis has lots of soft growth that is easily damaged by the wind if it is not secured.

Use garden twine to tie plants to their supports. If you are tying in large climbers with thicker stems, such as roses, you could use sturdy, flexible tube ties.

Pruning calendar: summer

Trees to prune

Summer is a good time to prune all trees, especially the stone fruits, such as cherries, flowering cherries, and plums (*Prunus*), and members of the rowan (*Sorbus*) family. These trees are prone to bacterial cankers, and pruning now helps to avoid these diseases. In late summer, prune espalier apple and pear trees.

Shrubs to prune

In early summer, prune *Garrya*. Shorten leggy growths on late-flowering *Camellias* after flowering has finished; if they have outgrown their situation, they can be hard-pruned now. Prune spring- and early summer-flowering shrubs like *Deutzia*, *Philadelphus*, shrubby *Lonicera*, *Kolkwitzia*, and *Weigela* so they grow plenty of new stems for next year's flowers. In late summer, prune *Escallonia*.

Climbers to prune

In early summer, trim *Clematis macropetala* and *C. alpina,* and trim overgrown *C. montana*. Prune leggy growth of wisterias to help flower bud production, and ivy (*Hedera*) if you didn't prune it in spring. After flowering, cut back climbing honeysuckles (*Lonicera*) and the old flowerheads of climbing hydrangeas (*Hydrangea petiolaris*).

Hedge care

Prune all types in late summer once nests are abandoned; berrying hedges can be left until spring to provide food for wildlife. Prune formal hedges at least twice in summer. Trim lavender (*Lavandula*) hedges lightly after flowering.



Prune all stone fruits, such as *Prunus serrula*.



You can prune ivy from spring to fall to keep it neat.

Main pruning tasks

Summer is the time to enjoy the results of your winter and spring pruning, but there are still important pruning jobs to do to keep your garden looking its best.

Formal hedges need to be trimmed several times during the summer to keep their clean, sharp edges. Topiary should also be trimmed a few times to maintain its shape. Do not prune boundary hedges until late summer.

Deadhead roses to encourage repeat flowering, and prune late spring- and early summer-flowering shrubs immediately after they have bloomed, since next year's flowers will be on stems made this year. Also prune back any shrubs, trees, or climbers that are putting on too much growth or causing an obstruction.

Other jobs to do now

Continue to train and tie in climbers during the summer. Climbing and rambling roses must be tied in regularly to protect long growths from wind damage, since they hold next year's flowering display. Also tie in Group 3 clematis to hold plants together, and wisteria to fill any gaps in coverage and to protect stems from wind damage.

Remove any diseased or dead growth on trees at any time. Dispose of diseased material by burning responsibly or taking it to a waste disposal site—don't compost it.

Trees can look quite different when clothed with leaves,so compare them in summer and winter before deciding what to prune. Leaves weigh down branches and can block paths or views, so some stems may need to be removed.

Pruning calendar: fall

Trees to prune

Fall is not a good time to prune trees as fungal spores can land on pruning cuts, increasing the risk of infection.

Shrubs to prune

Although most pruning jobs are best left until late winter or early spring, you should reduce the height of hybrid tea and floribunda roses by one-third to prevent their stems from rocking in winter winds and damaging the main stem and roots. Also remove *Buddleja* flowerheads and the top one-third of the shoots to stop the plant from self-seeding. Do not remove spent hydrangea flowerheads as they help to protect developing flower shoots from frost, and also provide attractive architectural structure in winter. Seedheads, fruits, and berries that are left on shrubs now have both wildlife and decorative value.

Climbers to prune

Fall is the ideal time to prune climbing and rambling roses. These plants still have sap in their stems, which makes them pliable and easy to train onto their supports. If the job is left until winter, the stems lose their flexibility and are more likely to snap. You can also prune Virginia creeper and Boston ivy (*Parthenocissus*) after leaf fall.

Hedge care

Any hedges not pruned in summer can be cut back now, but do not prune wildlife hedges, which are best left until spring, as their fruit and berries provide food for birds and other wildlife through the colder months.



Trees are prone to infections in fall, so do not prune them.



Prune the climber *Parthenocissus* after leaf drop.

Main pruning tasks

Don't prune trees and shrubs in the fall unless it is absolutely necessary. There are many fungal spores around at this time of the year and a high risk of diseases penetrating the cut surfaces.

It is, however, a good time to prune and train climbing and rambling roses as their stems are quite flexible and easily trained now. Reduce the height of hybrid tea and floribunda roses by one-third to prevent wind rock. Catch up with any pruning that you missed or didn't have time for in the summer, such as pruning back leggy growths on wisterias. It is also an ideal time to clean and sharpen pruning tools. Then sit back and admire the foliage and fruiting displays around you.

Other jobs to do now

Fall is tidying-up time. Cover trees or shrubs that need frost protection, such as palms, tree ferns, and fruits like apricots. Leave the fronds on tree ferns and palms, as they protect plants from frost. For further protection, tie them together over the crown.

As the leaves fall, the basic structure of plants becomes more visible, and you will be able to see more clearly what needs to be pruned in spring. Rake up fallen leaves and fruit, such as apples, and use to make compost and leafmold, which you can later spread under pruned plants to feed and mulch them.

If you have any logs left from pruning in the summer, you could construct a log pile, which benefits wildlife.

Pruning calendar: winter

Trees to prune

This is a good time to prune a wide range of trees and shrubs (with the exception of stone fruits) as you can clearly identify crossing branches and diseased wood. Prune trees with ornamental bark, such as *Acer davidii* and *Acer griseum* and birches. Apple and pear trees should also be pruned in winter.

Shrubs to prune

Prune any large or overgrown shrubs, such as *Mahonia* or *Philadelphus*, which can be cut back hard now or in early spring. You may lose the coming year's flowers by hard-pruning, but the plant will recover the following year.

Climbers to prune

Spur-prune wisteria in the winter, as the buds are not swelling and are less likely to be damaged. Also tackle *Actinidia* and Virginia creeper (*Parthenocissus*), and renovate overgrown ivies (*Hedera*). Remove long growths from around doors and window frames, and also where they have invaded gutters and grown under roof shingles. Shorten the main stems of all overly tall climbers, such as *Hydrangea petiolaris*.

Hedge care

Winter is the time for renovation work, reducing the height and width of overgrown hedges. Brush off snow from flat-topped hedges as its weight can damage their structure. Leave the crisp, bronzed foliage on hornbeam and beech hedges in the winter months because it adds ornamental value and also makes an excellent windbreak.



Prune apple trees in winter when their structure is more visible.



Brush snow off the top of hedges to prevent structural damage.

Main pruning tasks

Late winter or early spring is a good time to hard-prune overgrown shrubs, which are dormant at this time of the year. You can also see clearly the structure and naked silhouettes of trees, making them easier to prune. Summer is the ideal time to prune many trees, but winter is sometimes better because you may have more time to do the job properly. However, do not prune cherries and plums (*Prunus*), or members of the rowan (*Sorbus*) family.

You can also now admire the results of your earlier pruning efforts, with the attractive trunks and stems of trees and shrubs like the snakebark maple (*Acer davidii*), birch (*Betula*), cherry (*Prunus serrula*), and dogwood (*Cornus*) creating stunning winter features.

Other jobs to do now

Tie in anything that needs to be supported. At the same time, check that ties and supports have not been damaged during storms, or become too tight around stems and trunks. Bring berries and evergreen branches into the house for festive winter decorations.

You can dispose of pruning material (and old Christmas trees) in a variety of ways. Shred the woody waste to make a valuable mulching material, and compost soft growth. Burning material is an alternative method, but check your local regulations before you burn, and be considerate of neighbors. Alternatively, take all your off-cuts to your local waste disposal site, along with any diseased material, if you do not plan to burn it.

Root vegetables: potatoes

Potato '*Red Duke of York*'
A vigorous first early, producing abundant, good-sized, red-skinned tubers with delicious pale yellow flesh. Perfect in salads when small, and boiled or baked when larger. Young shoots need protection from frost.

Plant: early spring
Harvest: early to midsummer
💧◑☼

Potato '*Foremost*'
Harvest this useful early variety from early summer or lift as required throughout the summer. The white-skinned, white-fleshed crop has a firm texture, ideal for salads and boiling. Protect young shoots from frost.

Plant: early spring
Harvest: early to late summer
💧◑☼

Potato '*Arran Pilot*'
A popular first early, excellent for gardeners eager to enjoy large yields of small potatoes with creamy, waxy flesh. Good scab resistance and tolerance of dry spells. Young shoots need protection from frost.

Plant: early spring
Harvest: early to midsummer
💧◑☼













Potato '*Mimi*'
The ideal first early for containers, producing masses of small red tubers with incredibly tasty, waxy, cream-colored flesh. An excellent salad potato with good scab resistance. Protect new shoots from frost.

Plant: early spring
Harvest: early summer
💧◑☼

Potato '*Charlotte*'
A supermarket favorite because of its long, smooth, yellow tubers, with fabulously flavored, waxy flesh. This second early is easy to grow in the garden, and one of the best salad potatoes.

Plant: mid-spring
Harvest: mid- to late summer
💧◑☼

Potato '*Saxon*'
For baking, boiling, and french-frying, try this floury-textured second early. The large, white tubers have a mild, creamy flavor, and the plants display a useful resistance to both blackleg and eelworm.

Plant: mid-spring
Harvest: mid- to late summer
💧◑☼

Potato '*Royal Kidney*'
An old maincrop salad variety, 'Royal Kidney' produces delicious, yellow-fleshed salad potatoes from late summer. It is also tempting to dig up the plants earlier for crops of tender baby potatoes.

Plant: mid-spring
Harvest: late summer

Potato '*Ratte*'
The long, slightly knobby tubers harvested from this maincrop variety are a real treat. Their dense, waxy, yellow flesh has a strong nutty flavor, making them perfect for salads.

Plant: mid-spring
Harvest: late summer

Potato '*Pink Fir Apple*'
A curious old maincrop variety, producing long, irregular tubers with pink-tinged skin that is best left on during cooking. The waxy flesh, with its earthy flavor, is popular in salads, and the tubers store well.

Plant: mid-spring
Harvest: from early fall













Potato '*Kerrs Pink*'
This versatile and high-yielding maincrop variety is reliable in most soils. The blush pink tubers have delicious floury cream flesh that is perfect for mashing, french-frying, roasting, and baking. Stores well.

Plant: mid-spring
Harvest: from early fall

Potato '*Sante*'
An excellent choice for organic gardeners because of its excellent pest and disease resistance, this maincrop variety yields large cream tubers that are great for baking, boiling, and roasting. Stores well.

Plant: mid-spring
Harvest: from late summer

Potato '*Nicola*'
Resistance to eelworm and blight makes this variety a good option for maincrop salad potatoes. Large crops of long, yellow, waxy tubers are reliably produced and store well over winter.

Plant: mid-spring
Harvest: from late summer

Root vegetables: carrots, beets, parsnips

Carrot *'Parmex'*
Dumpy, spherical roots make this one of the best carrots for sowing into patio pots or shallow soil. Despite their shape, they have a fine sweet flavor. The earliest crops can be sown under glass or protected with cloches.

Sow: early to late spring
Harvest: late spring to early fall

Carrot *'Infinity'* F1
This late maincrop carrot has an elegant, slender root that is delicious raw or cooked. The sweet carrots are deep orange right to their core and keep well in the soil into fall or can be lifted and stored successfully.

Sow: early spring to midsummer
Harvest: late summer to late fall

Carrot '*Flyaway*' F1
Specially bred to be less prone to attack by carrot flies, this maincrop carrot produces good crops where the pest would render others inedible. The thick, cylindrical roots are smooth-skinned and sugary.

Sow: early spring to midsummer
Harvest: late spring to mid-fall








Carrot '*Purple Haze*' F1
As its name suggests, this variety has unconventional dark purple roots, which reveal contrasting orange cores when they are sliced. Flavor is not sacrificed and is particularly good when raw.

Sow: early spring to early summer
Harvest: early summer to late fall

Carrot '*Bangor*' F1
Long, stocky roots are produced in large quantities, especially in moist soil, by this excellent maincrop variety. Crops can be harvested from late summer and throughout fall, and store well once lifted.

Sow: mid-spring to early summer
Harvest: midsummer to late fall

Carrot '*Carson*' F1
Fall and winter bring good crops of this medium-sized, tapering variety. The rich orange color, combined with the delicious crunchy texture and sweetness, makes them irresistible when eaten raw.

Sow: mid-spring to midsummer
Harvest: late summer to early winter

Beet '*Boltardy*'
A reliable variety yielding traditional deep red globe-shaped roots with a fine sweet flavor. Perfect for sowing under cloches in early spring because of its excellent resistance to bolting.

Sow: early spring to midsummer
Harvest: early summer to mid-fall

Beet '*Chioggia Pink*'
A beautiful curiosity; the rich red skin of this spherical root conceals flesh marked with concentric rings of blush pink and white. Its sweet, mild flavor is delightful raw or cooked.

Sow: mid-spring to midsummer.
Harvest: early summer to mid-fall

Beet '*Forono*'
Elongated, burgundy-colored roots make this variety ideal for slicing. Tender young roots have a particularly intense flavor, so sow successionally for a continuous supply. Prone to bolting if sown too early.

Sow: mid-spring to early summer
Harvest: midsummer to late fall













Beet '*Pablo*' F1
One of the best varieties for growing in patio containers and perfect to harvest as baby beets. The smooth, deep red, spherical roots taste exceptionally sweet; they also stand well in the soil without bolting or becoming woody.

Sow: mid-spring to early summer
Harvest: midsummer to mid-fall

Parsnip '*Gladiator*' F1
A popular hybrid parsnip that matures quickly, producing consistently reliable, early-maturing crops of white-skinned roots. 'Gladiator' also benefits from good canker resistance.

Sow: late winter to mid-spring
Harvest: mid-fall to early spring

Parsnip '*Tender and True*'
In deep soil, this variety forms exceptionally long roots, which are often considered to have one of the finest parsnip flavors. It is also resistant to canker and is a firm favorite with exhibition growers.

Sow: late winter to mid-spring
Harvest: late fall to early spring

Root vegetables: turnips, rutabagas, radishes

Turnip '*Snowball*'
For a quick crop, this fast-maturing variety is one of the best. The pure white globes are best harvested while young, when their deliciously crisp, firm, white flesh can be enjoyed raw or cooked.

Sow: early spring to midsummer
Harvest: late spring onward

Turnip '*Purple Top Milan*'
A good choice for early sowings under cloches, this turnip crops reliably and matures quickly. The flat-topped roots are a vivid shade of purple above the soil and pure white beneath it, making them attractive as well as delicious.

Sow: early spring to midsummer
Harvest: mid-spring onward

Rutabaga '*Brora*'
This gem among rutabagas has the classic purple top and cream base, but has been bred to produce the finest smooth flesh without any bitterness. Best harvested in early winter to avoid woodiness.

Sow: late spring to midsummer
Harvest: mid-fall to midwinter








Radish '*French Breakfast*'
A torpedo-shaped variety with rosy red skin and a bright white tip. Its shape makes it great for slicing, and the crunchy flesh has a mild flavor with just a hint of peppery heat. Easy and quick to grow.

Sow: early spring to early summer
Harvest: late spring to mid-fall

Radish '*Cherry Belle*'
Probably one of the best vegetables for the absolute beginner, these small, round, brilliant red radishes tolerate poor-quality soil. They grow rapidly, are slow to become woody, and have tasty, mild-flavored flesh.

Sow: early spring to early summer
Harvest: late spring to mid-fall

Chinese radish *'Mantanghong'* F1
For a taste of the exotic, try these easy-to-grow, tennis-ball-sized radishes. Their plain, pale green skin hides vivid magenta flesh with a white outer layer, which has a nutty flavor and a touch of heat.

Sow: early summer to midsummer
Harvest: late summer to early winter

Brassicas: cabbages

Cabbage '*Pixie*'
One of the earliest pointed cabbages, which can be picked young as spring greens or allowed to mature into a firm-hearted cabbage. A reliable crop that can be harvested in time to leave soil clear for spring sowings.

Sow: midsummer
Harvest: midwinter to late spring

Cabbage '*Derby Day*'
A traditional, pale green ballhead cabbage for early summer harvest. Its resistance to bolting has long made it popular with gardeners, and the mature cabbages can stand even summer heat.

Sow: late winter to early spring
Harvest: early to late summer

Cabbage '*Hispi*' F1
Another favorite, this pointed cabbage reliably produces compact, tasty, dark green heads. The cabbages mature rapidly, and successional sowings provide a harvest from late spring into fall.

Sow: late winter to late summer
Harvest: late spring to late fall



Cabbage '*Marner Early Red*' (syn. '*Marner Fruerot*')
This dense-hearted cabbage is one of the first reds to reach maturity. The outer leaves are tinged with gray; the head is an intense red and has a peppery flavor best appreciated raw.

Sow: midwinter to early spring
Harvest: midsummer to late summer

Cabbage '*Minicole*' F1
Ideal for small gardens, this white ballhead cabbage produces small, uniform heads on compact plants. Plant closely for a bumper harvest of fall cabbages, which will stand in the ground for up to three months.

Sow: early to late spring
Harvest: early fall to early winter

Cabbage '*Red Jewel*' F1
The claret-colored leaves dusted with silver make this one of the best cabbages for ornamental plantings. The tight round heads also taste delicious and will stand in the ground well or store indoors.

Sow: early spring to early summer
Harvest: midsummer to early fall

Brassicas: cabbages, calabrese, broccoli, cauliflower

Cabbage '*January King 3*'
This traditional winter cabbage has good frost resistance and appetizing, sweet, crunchy leaves. The frilly-edged leaves are tinged with pink and also look beautiful in the winter garden.

Sow: mid-spring to early summer
Harvest: late fall to late winter

Cabbage '*Tundra*' F1
A cross between a savoy and a white cabbage, this extremely hardy variety produces solid round heads of tasty crisp leaves. The long cropping season makes this a really useful addition to the vegetable patch.

Sow: early spring to early summer
Harvest: mid-fall to early spring

Cabbage '*Savoy Siberia*' F1
A truly tough vegetable, this savoy withstands hard winters, so is ideal for exposed or cold gardens. The blue-green, blistered leaves taste sweet, and the cabbages stand well in the ground for long periods.

Sow: early spring to early summer
Harvest: early fall to midwinter








Calabrese '*Corvet*' F1
A reliable variety of fall vegetable, producing robust plants and a bumper crop of dense, green heads. Cut the central head while its flowers are still tightly closed for a second harvest of smaller shoots a few weeks later.

Sow: mid- to late spring
Harvest: late summer to early fall

Broccoli '*Bordeaux*'
This purple sprouting variety is very useful for those who can't wait until spring for broccoli. It is not winter-hardy and does not require the usual exposure to cold to produce its tasty spears.

Sow: late winter to mid-spring
Harvest: midsummer to mid-fall

Broccoli '*White Star*'
Creamy white rather than purple flowers make the spears of this spring variety reminiscent of cauliflower; many consider the taste similar, too. Reliably high yields produced over a long period make it a popular choice.

Sow: mid- to late spring
Harvest: early to mid-spring

Broccoli '*Claret*' F1
A large, vigorous plant that may need staking in windy gardens, this variety produces huge yields of chunky, succulent spears in spring. The purple flowerheads are tightly packed and uniform, and taste delicious.

Sow: mid- to late spring
Harvest: early to mid-spring
💧 ☼

Broccoli '*Late Purple Sprouting*'
To extend your broccoli crop into late spring, try this slightly later-flowering variety. It is slow to go to seed, and the delicious purple-budded spears can be cut over a long period.

Sow: mid- to late spring
Harvest: early to late spring
💧 ☼

Cauliflower '*Walcheran Winter Armado April*'
An extremely hardy winter variety that tolerates heavy frost and produces large, solid, pure white heads. It ties up a bed for 12 months, so it may not be suitable for very small gardens.

Sow: mid- to late spring
Harvest: early to late spring
💧 ◑ ☼













Cauliflower '*Mayflower*' F1
High-quality, dense white curds are consistently produced by this vigorous early summer variety. Unlike many others, it does not require high nitrogen levels and is harvested early enough to avoid midsummer droughts.

Sow: mid- to late winter and mid-fall **Harvest:** late spring to midsummer 💧 ◑ ☼

Cauliflower '*Romanesco*'
If you want something different, try this strange summer/fall variety, with pyramid-shaped heads in a vibrant shade of acid green. Grow over a long season for large heads or sow successionally for frequent small crops.

Sow: early to late spring
Harvest: late summer to early winter
💧 ◑ ☼

Cauliflower '*Violet Queen*' F1
The vivid purple curds formed by this variety will brighten up any vegetable patch, although they turn green when cooked. Plenty of nitrogen and water are required to sustain strong growth.

Sow: late spring to early summer
Harvest: late summer to early fall
💧 ◑ ☼

Brassicas: Brussels sprouts, kale, kohlrabi, oriental greens

Brussels sprouts '*Red Delicious*'
This magnificent variety is a striking shade of red-tinged-purple from its crowning leaves to the base of its stem. Unlike many other red varieties, the sprouts retain their color after cooking and have a fine flavor.

Sow: early to mid-spring
Harvest: early winter

Brussels sprouts '*Trafalgar*' F1
If your aim is sweet sprouts for Christmas, then this variety will not disappoint. Dense crops of firm, uniformly-sized sprouts grow on tall, sturdy plants and can be harvested throughout the winter.

Sow: early to mid-spring
Harvest: late fall to midwinter

Brussels sprouts '*Bosworth*' F1
Dark green, dense, sweet sprouts are produced in abundance by this tough hybrid variety, which will stand well through cold winter weather. Some tolerance to downy mildew helps ensure a healthy crop.

Sow: early to mid-spring
Harvest: late fall to early winter








Kale '*Redbor*' F1
All kales are useful hardy winter crops, but the tall leaves of this variety resemble large clumps of burgundy, curly-leaved parsley and add some welcome color to dull days. Great steamed or stir-fried.

Sow: early to late spring
Harvest: early fall to early spring

Kale '*Starbor*' F1
More compact than most kales, this variety is well suited to the small or windswept garden. The tightly curled green leaves stand up well to winter cold. Try successional sowings for a year-round crop of tasty baby leaves.

Sow: early spring to early summer
Harvest: early fall to early spring

Kale '*Nero di Toscana*'
Also known as Black Tuscany or Cavolo Nero, this is the favored kale in Italian kitchens. Its upright leaves are almost black and blistered like those of savoy cabbages. Use mature leaves in soups and stews, baby ones in salads.

Sow: early spring to early summer
Harvest: early fall to early spring

Kohlrabi '*Olivia*' F1
Harvest the swollen stem that sits just above soil level when it is about the size of a tennis ball, and enjoy the crisp, white flesh grated raw in salads or lightly steamed. Reliable, with little woodiness, this variety is slow to bolt.

Sow: early spring to early summer
Harvest: late spring to mid-fall

Kohlrabi '*Purple Danube*' F1
The vibrant purple skin and stems of this variety are striking in the garden, and its sweet nutty flavor is one of the best. Purple varieties take longer to mature than white, so this makes a good late summer and fall crop.

Sow: mid-spring to early summer
Harvest: midsummer to late fall

Bok choy '*Joi Choi*'
Summer stir-fries will be fresher and tastier with the addition of these succulent, crispy, home-grown leaves. This variety has attractive bright white stems that carry deep green, rounded leaves, and it is easy to grow.

Sow: mid-spring to early fall
Harvest: early summer to mid-fall








Mizuna
Often found in supermarket salad mixes, these jagged-edged, slightly mustard-flavored leaves are simple to cultivate over summer. Harvest baby leaves for salads or allow plants to mature and use leaves for stir-frying.

Sow: early spring to early fall
Harvest: late spring to late fall

Mibuna
Similar in flavor to mizuna, but with a stronger peppery tang and long, smooth-edged foliage. Like mizuna, this is an ideal cut-and-come-again crop that can be sown successionally from spring to fall.

Sow: early spring to early fall
Harvest: late spring to late fall

Mustard '*Red Giant*'
Another beautiful, strongly flavored leaf, this ruby-tinged mustard is best harvested while the leaves are small, otherwise the peppery flavor can be overpowering. Hardy enough to stand over winter from a fall sowing.

Sow: early spring to early fall
Harvest: late spring to midwinter

Salad and leafy vegetables: lettuce, spinach, arugula

Lettuce '*Sangria*'
This butterhead type matures to form a loose heart with soft leaves, and a pretty red flush that will brighten up a salad. Easy to grow and quick to mature, it does well in poorer soil and has some resistance to mildew.

Sow: early spring to late summer
Harvest: late spring to mid-fall

Lettuce '*Tom Thumb*'
A gardeners' favorite, this compact, green butterhead lettuce rapidly forms dense, sweet-tasting hearts. Ideal for small gardens because it can be planted at high densities and is ready for harvest quickly.

Sow: early spring to midsummer
Harvest: late spring to early fall

Lettuce '*Little Gem*'
This cos lettuce is familiar from the supermarket shelves, but is even crisper and sweeter if you grow it yourself. Its diminutive size makes it perfect for small gardens, and it is one of the fastest-cropping cos types.

Sow: early spring to midsummer
Harvest: late spring to early fall













Lettuce '*Freckles*'
This semi-cos variety forms an open head with green leaves that are spectacularly splattered with red. A good choice for flower borders, where it matures quickly. Plants are slow to bolt, even in warm weather.

Sow: early spring to late summer
Harvest: late spring to mid-fall

Lettuce '*Delicato*'
Loose leaf lettuces are the quickest and easiest to grow, either as cut-and-come-again baby leaves or for harvesting whole when mature. This deep red oakleaf variety has a pleasant flavor.

Sow: early spring to midsummer
Harvest: mid-spring to mid-fall

Lettuce '*Catalogna*'
A tasty, green oakleaf lettuce that you will not want to forget to sow successionally all through summer. The tender leaves have a fine flavor and the non-hearting plants are slow to bolt, should they get the chance.

Sow: early spring to midsummer
Harvest: mid-spring to mid-fall

Lettuce '*Lollo Rossa-Nika*'
The red leaves of this frilled lettuce are so dark as to be almost purple and are incredibly ornamental as well as appetizing. Young leaves taste sweet, and, although they turn bitter as they grow, the curled heads look fabulous.

Sow: early spring to midsummer
Harvest: late spring to mid-fall

Lettuce '*Challenge*'
Crisphead lettuces are similar to the iceberg types. This reliable variety forms large, solid hearts of crunchy leaves and performs well when sown early and late under cloches. Good resistance to mildew and bolting.

Sow: early spring to midsummer
Harvest: late spring to mid-fall

Lettuce '*Sioux*'
A pretty red-tinged iceberg variety, with leaves that intensify in color in warmer weather, giving the plants good ornamental qualities that are so valuable in small gardens. Perfect color and crunch for salads.

Sow: early spring to midsummer
Harvest: early summer to mid-fall













Spinach '*Perpetual Spinach*'
Not a true spinach, but spinach beet, with a taste similar to Swiss chard. It is easy to grow because it rarely runs to seed, even in dry conditions. Succulent green leaves are produced prolifically and crops can be gathered all winter.

Sow: mid-spring to midsummer
Harvest: any time

Spinach '*Tetona*' F1
A high-yielding spinach producing a profusion of rounded dark green leaves. This is the perfect variety for sowing as a cut-and-come-again crop to produce baby leaves for salads, but it can also be left to mature.

Sow: early spring to late summer
Harvest: late spring to late fall

Arugula '*Apollo*'
This cultivated variety has large, rounded, green leaves and a strong peppery flavor without any bitterness. The plant is easy to grow as a cut-and-come-again crop in pots or in the ground. Water well in hot weather.

Sow: early spring to midsummer
Harvest: mid-spring to mid-fall

Leafy vegetables: arugula, chicory, Swiss chard

Arugula '*Rocket Wild*'
A popular salad leaf with slim, divided leaves and a pungent peppery taste. Easy to grow in pots or beds, it does not bolt as quickly as cultivated forms, but pick the leaves frequently for a longer cropping period.

Sow: early spring to early fall
Harvest: from mid-spring (through winter under cover) ◑ ◊ ☼ ☀

Chicory '*Italiko Rosso*'
Red-stemmed asparagus, or catalogna chicory, grows well in poor soil and is ideal for harvesting as baby leaves to add a slightly bitter tang to salads. Alternatively, allow the foliage to mature and eat lightly steamed.

Sow: late spring to early fall
Harvest: midsummer to late fall
◊ ☼ ☀

Chicory '*Sugar Loaf*'
Treat in the same way as lettuce to produce tall, pale heads of crisp, bitter leaves or cut-and-come-again baby leaves. Chicory grows well in poorer soil, although watering may be required in dry spells.

Sow: mid-spring to late summer
Harvest: midsummer to mid-fall
◊ ☼ ☀



Swiss chard '*Bright Lights*'
Multicolored stems ranging from white and yellow to pink and purple make this a vibrant addition to the vegetable garden and flower border. Easy to grow, it reemerges in early spring if given winter protection.

Sow: mid-spring to midsummer
Harvest: early spring to mid-fall
◑ ◊ ☼

Swiss chard '*Charlotte*'
One of the most attractive ruby chards, with bright red stems and contrasting green leaves veined a striking red. It looks fabulous in a pot or flower border, and the baby leaves liven up salads. A must for every garden.

Sow: mid-spring to midsummer
Harvest: at any time
◑ ◊ ☼

Swiss chard '*Lucullus*'
Decorative and delicious, this chard rapidly produces generous crops of large green leaves on sturdy, pure white stems. Leaves and stems may be boiled, steamed, or stir-fried; their mild flavor is similar to beets.

Sow: mid-spring to midsummer
Harvest: early spring to mid-fall
◑ ◊ ☼

Cucurbits: zucchini, summer squash

Zucchini '*Zucchini*'
A reliable variety that forms a bushy plant, well suited to growing in a container. Zucchini with dark green skins and tasty pale flesh are produced in profusion from midsummer. Like all zucchini, they are best picked young.

Sow: mid-spring to early summer
Harvest: midsummer to early fall
◊ ◑ ☼

Zucchini '*Defender*' F1
A phenomenally productive early variety. If harvested small, fruits will keep coming until mid-fall, and they are delicious. Plants are resistant to cucumber mosaic virus, which can cause other varieties to fail.

Sow: mid-spring to early summer
Harvest: midsummer to mid-fall
◊ ◑ ☼

Zucchini '*Burpee's Golden*'
Another prolific zucchini variety that bears numerous decorative and delicious bright yellow fruits. The zucchini have a particularly fine flavor, especially when harvested small.

Sow: mid-spring to early summer
Harvest: midsummer to early fall
◑ ◊ ☼













Zucchini '*Tromboncino*'
This vigorous Italian variety is best trained up a sunny wall to afford everyone a good view of its long, curved, bulbous-ended fruits. The pale green fruits can reach more than 12 in (30 cm) long.

Sow: mid-spring to early summer
Harvest: midsummer to early fall
◑ ◊ ☼

Zucchini '*Venus*' F1
Unusually compact, these plants are great for containers or small gardens, and still produce ample crops of delicious, mid-green zucchini. In good conditions, fruits are ready to harvest 60 days after planting.

Sow: mid-spring to early summer
Harvest: early summer to mid-fall ◑ ◊ ☼

Summer squash '*Long Green Bush*'
Despite its name, this variety forms quite a compact, bushy plant, making it suitable for the smaller garden. Long, deep green fruits, with pale green marrow stripes, swell rapidly, but can be picked as zucchini when small.

Sow: mid-spring to early summer
Harvest: midsummer to mid-fall
◑ ◊ ☼

Cucurbits: squash, cucumbers

Squash '*Sunburst*' F1
A yellow "patty pan" variety, this squash has vibrant butter-colored fruits, shaped like flying saucers. Large crops of flavorsome fruits are produced by this easily grown variety if regular harvesting is carried out.

Sow: mid-spring to early summer
Harvest: midsummer to mid-fall

Squash '*Uchiki Kuri*'
Also known as 'Red Kuri', this squash produces several medium-sized, bright orange fruits, with delicious, nutty, golden flesh. It performs particularly well in temperate climates. Fruits store well once cured.

Sow: mid- to late spring
Harvest: late summer to mid-fall

Squash '*Pilgrim Butternut*' F1
A less vigorous and so more manageable butternut squash for the smaller garden. The semi-bush habit of the vine does not prevent a good crop of beige-skinned, orange-fleshed squashes, which store well.

Sow: mid- to late spring
Harvest: late summer to mid-fall













Squash '*Crown Prince*' F1
This trailing squash is a favorite because of its exceptionally good nutty-flavored flesh. The steely gray skin of the fruits contrasts dramatically with the orange flesh and looks attractive on the vine.

Sow: mid-spring to late spring
Harvest: late summer to mid-fall

Squash '*Turk's Turban*'
Not an exceptional culinary squash, with pale yellow flesh and a turnip-like flavor, but often grown for its ornamental qualities. The rich orange skin folds and forms a bulge splashed with green and cream.

Sow: mid- to late spring
Harvest: late summer to mid-fall

Squash '*Festival*' F1
Ornamental and delicious, this trailing vine produces high yields of small, squat, orange-and-cream-striped squashes, with sweet, nutty-tasting, cream flesh. The squashes are perfect for stuffing or baking, and store well.

Sow: mid- to late spring
Harvest: late summer to mid-fall

Cucumber '*Bush Champion*' F1
Grow this ridge cucumber outdoors—its compact plants are ideal for small gardens and pots, and have good tolerance to cucumber mosaic virus. The slightly knobby, dark green, sweet fruits reach about 4 in (10 cm) long.

Sow: mid-spring to early summer
Harvest: late summer to mid-fall
☼ ◑ ☼

Cucumber '*Marketmore*'
An excellent, high-yielding cucumber, producing sturdy, deep green fruit up to 8 in (20 cm) long, with no bitterness. This variety does well outdoors on a teepee or trellis. Resistance to cucumber mosaic virus is a bonus.

Sow: mid-spring to early summer
Harvest: late summer to mid-fall
☼ ◑ ☼

Cucumber '*Masterpiece*'
Crisp, juicy, white flesh, under a deep green, slightly spiny skin, makes this ridge cucumber a good choice for outdoor cultivation. This variety crops reliably, but performs best when allowed to climb.

Sow: mid-spring to early summer
Harvest: late summer to mid-fall
☼ ◑ ☼













Cucumber '*Zeina*' F1
An all-female variety that can be grown in the greenhouse or outdoors. Small, succulent, smooth-skinned cucumbers can be harvested over a long season and are a handy size to eat at one meal.

Sow: early spring to early summer
Harvest: midsummer to mid-fall
☼ ◑ ☼

Cucumber '*Petita*' F1
For an abundance of juicy, miniature cucumbers from the greenhouse, this is the variety to choose. It is easy to grow, even in difficult conditions, and has all female flowers so bitter fruits are not produced.

Sow: early spring to early summer
Harvest: midsummer to mid-fall
☼ ◑ ☼

Cucumber '*Carmen*' F1
Resistance to powdery mildew, scab, and leaf spot makes this all-female variety a good choice for greenhouse cultivation. Impressive harvests of straight, smooth, green fruits are simple to produce.

Sow: early spring to early summer
Harvest: midsummer to mid-fall
☼ ◑ ☼

Allium family: onions, shallots, green onions

Onion '*Ailsa Craig*'
An old favorite, this reliable variety yields heavy crops of large, sweet onions, with smooth yellow-brown skin. Best sown as seed in spring to produce a good fall crop that stores well if allowed to dry.

Sow: late winter to early spring
Harvest: late summer to early fall
💧 ☼

Onion '*Sturon*'
Traditionally grown from sets, this variety produces large, round, yellow-brown bulbs that have a strong skin, which makes them an excellent choice for winter storage. Seed is occasionally available.

Plant sets: late winter to early spring
Harvest: late summer to early fall
💧 ☼

Onion '*Red Baron*'
Widely available as both seeds and sets, this variety has a rich red skin, with pronounced pink stripes between the bulb's layers. It will store for only a limited time.

Sow: late winter to mid-spring
Plant sets: early spring
Harvest: early to mid-fall
💧 ☼













Onion '*Senshyu*'
Sets of this useful winter Japanese variety should be planted in fall and seeds sown a little before for an early summer harvest. The semi-flat, straw-colored bulbs grow to a good size and have a strong flavor.

Sow: late summer
Plant sets: early to mid-fall.
Harvest: early to midsummer 💧 ☼

Onion '*Shakespeare*'
For an early summer crop of globe-shaped onions with rich brown skins, try this British overwintering variety. The dense white flesh and sturdy skin mean that they store well, and they have an excellent flavor.

Sow: early to mid-fall
Harvest: early to midsummer
💧 ☼

Shallot '*Longor*'
An attractive, elongated variety of shallot, with a pink flush to the skin and inner layers. The strongly flavored bulbs store well through fall and winter if carefully dried. Quicker to crop than traditional bulb onions.

Plant sets: late winter to mid-spring
Harvest: mid- to late summer
💧 ☼

Shallot '*Red Sun*'
One of the most reliable red shallots, this variety has wonderful burgundy skin and white flesh with layers divided by pink rings. Appetizing chopped raw in salads, it is also well suited to cooking and pickling.

Plant sets: early to mid-spring
Harvest: mid- to late summer
💧☼

Shallot '*Golden Gourmet*'
Large and yellow-skinned, this high-yielding variety produces bumper crops of good-quality bulbs from sets and is easy to store all through the winter. It is less prone to bolting in dry conditions than many shallots.

Plant sets: late winter to mid-spring
Harvest: mid- to late summer
💧☼

Green onion '*Paris Silverskin*'
A dual-purpose small white onion that can be harvested young as a salad onion or left in the ground to bulb up for pickling. Easy to grow and compact, it makes an ideal crop for small gardens.

Sow: early to mid-spring
Harvest: mid- to late summer
💧☼













Green onion '*Guardsman*'
This trusted, white-stemmed variety is extremely easy to grow. It is a good choice to sow successionally from spring to fall because it is hardy enough to overwinter and give an early spring crop. Resistant to white rot.

Sow: early spring to mid-fall
Harvest: late spring to mid-fall; late winter to early spring 💧☼

Green onion '*North Holland Blood Red*'
An attractive variety with bold red bases and a mild flavor. Use thinnings from early sowings as green onions, leaving wider-spaced plants to develop into red-skinned maincrop onions.

Sow: early spring to early summer
Harvest: late spring to late summer
💧☼

Green onion '*White Lisbon*'
A trusted old favorite, this variety produces white bulbs and bright green tops with a good, strong flavor. It is easy to grow but prone to downy mildew, so keep rows well spaced to avoid the spread of disease.

Sow: early spring to midsummer
Harvest: late spring to early fall
💧☼

Allium family: leeks, garlic

Leek '*Musselburgh*'
An extremely hardy, sturdy leek, with a broad white stem topped by impressive green leaves, known as flags. This old variety can withstand the coldest winter, and can be harvested from late fall until late winter.

Sow: early to mid-spring
Harvest: late fall to late winter
💧 ☼

Leek '*Hannibal*'
This handsome leek has deep green leaves and a long, white, straight stem. Suitable for fall and early winter cropping, it also produces impressive mini leeks when planted close together.

Sow: early to mid-spring
Harvest: early fall to early winter
💧 ☼

Leek '*Swiss Giant, Zermatt*'
An elegant variety with a long, slender stem, which despite its name forms excellent mini leeks when planted at high densities. It is ready for harvest by late summer—an advantage for those with limited space in the garden.

Sow: early to mid-spring
Harvest: midsummer to late fall
💧 ☼








Garlic '*Solent Light*'
One of the best garlics for cool climates, this is best planted in fall but also does well planted in spring. It matures in late summer and because it is a nonflowering, softneck type, stores extremely well.

Plant cloves: mid-fall to early spring
Harvest: midsummer to early fall 💧 ☼

Garlic '*Early Light*'
This flowering, hardneck, purple-skinned variety is best used fresh but will store for about three months. The harvest will be eagerly anticipated, as this is one of the earliest varieties to crop in cool climates.

Plant cloves: mid-fall to midwinter
Harvest: late spring to early summer
💧 ☼

Garlic '*Elephant Garlic*'
Closely related to the leek, this giant produces bulbs up to 4 in (10 cm) in diameter. Use the large, juicy cloves fresh from the soil to enjoy their mild, sweet flavor, which makes them particularly suitable for roasting.

Plant cloves: mid-fall to midwinter.
Harvest: midsummer to early fall
💧 ☼

Legumes: peas

Pea '*Feltham First*'
Early and dwarf, this is a useful, high-yielding pea variety for small gardens. Better results are often achieved from fall sowings in containers, where plants are given some protection.

Sow: mid- to late fall; midwinter to early spring
Harvest: late spring to midsummer
◑ ◊ ☼

Pea '*Twinkle*'
An excellent early variety, the first sowings of which perform best if protected under cloches when young. Dwarf plants give good crops of full pods and have resistance to pea wilt and tolerance to downy mildew.

Sow: late winter to mid-spring
Harvest: late spring to midsummer
◑ ◊ ☼

Pea '*Hurst Greenshaft*'
Pairs of long pods develop high on these plants, making harvesting of this traditional variety's consistently large crops somewhat easier. The peas are large and sweet, and plants have good disease resistance.

Sow: early spring to early summer
Harvest: late spring to early fall
◑ ◊ ☼








Pea '*Rondo*'
One of the tastiest and heaviest cropping peas, this double-podded variety has dark green, straight pods up to 4 in (10 cm) long. Plants need supports, but the succulent peas should be ample reward.

Sow: early spring to early summer
Harvest: late spring to early fall
◑ ◊ ☼

Pea '*Sugar Snap*'
A versatile sugar snap variety that can be picked young and eaten whole, raw, or stir-fried, or harvested when mature and podded for fresh peas. Plants grow up to 6 ft (1.8 m) tall, and need support from trellis or canes.

Sow: early spring to early summer
Harvest: late spring to late summer
◑ ◊ ☼

Pea '*Oregon Sugar Pod*'
An excellent snow pea variety that produces wide, flat pods best eaten whole, either raw, steamed, or stir-fried. Expect large yields of these crisp, sweet pods from plants that grow to 36 in (90 cm).

Sow: early spring to early summer
Harvest: late spring to late summer
◑ ◊ ☼

Legumes: beans

Runner bean '*Butler*'
This attractive, red-flowered runner bean grows vigorously and forms many long, stringless pods filled with pretty purple beans. They can be picked over a long season and, being stringless, are still palatable when a little larger.

Sow: mid-spring to early summer
Harvest: midsummer to mid-fall

Runner bean '*Liberty*'
A favorite with exhibitors, this runner bean has glorious scarlet flowers followed by extremely long (up to 18 in/45 cm) pods. The heavy crops of smooth-skinned pods are prized for their tasty, thick flesh.

Sow: mid-spring to early summer
Harvest: midsummer to mid-fall

Runner bean '*White Lady*'
The pure white flowers of this runner bean are thought to be less attractive to birds. Hot weather can prevent pods from setting on other varieties, but 'White Lady' still performs well, making it suitable for later sowings.

Sow: mid-spring to early summer
Harvest: midsummer to mid-fall



Runner bean '*Wisley Magic*'
A runner bean with bright red flowers that develop into slim pods up to 14 in (35 cm) long, with a delicious fresh flavor. The plants grow rapidly and produce good yields, but pods are not stringless so are best harvested young.

Sow: mid-spring to early summer
Harvest: midsummer to mid-fall

French bean '*Purple Queen*'
Perfect for a container or border, this compact dwarf French bean grows without supports and develops heavy crops of glossy, rich purple pods. The stringless pods have a fine flavor and turn green when cooked.

Sow: mid-spring to midsummer
Harvest: early summer to late fall

French bean '*Delinel*'
A dwarf bean for a bumper crop. In containers or beds, it produces large yields of rounded, long green beans with a firm texture and good flavor. Plants are resistant to common bean mosaic virus and anthracnose.

Sow: mid-spring to midsummer
Harvest: early summer to late fall

French bean '*The Prince*'
This dwarf variety has long, flat, green pods, best harvested young when they are stringless. The flavor is excellent, and crops can be reliably harvested by early summer. They are also produced over a long period.

Sow: mid-spring to midsummer
Harvest: early summer to late fall

French bean '*Ferrari*'
A fine dwarf French bean—slim, succulent, bursting with flavor, and stringless. The plants do well sown in mid-spring if protected from frost, and thrive in containers. The connoisseur's choice, as well as easy to grow.

Sow: mid-spring to midsummer
Harvest: early summer to late fall

French bean '*Cobra*'
Train up a teepee or trellis to achieve large crops of stringless, tender green beans, up to 8 in (20 cm) long. The flowers are an unusual shade of violet, which make the plants ornamental as well as productive.

Sow: mid-spring to midsummer
Harvest: early summer to late fall













Borlotto '*Lingua di Fuoco*'
Grown in the same way as a climbing French bean, this Italian cranberry bean has long, flattish, pale green pods marked with red. Eat whole when young or remove the purple-blotched seeds from mature pods and dry them.

Sow: mid-spring to midsummer
Harvest: early summer to late fall

Fava bean '*Aquadulce Claudia*'
An old favorite, this hardy fava bean can overwinter outdoors. Plants grow to 3 ft (90 cm) and yield a good crop of tender white beans in "cotton gauze" lined pods. Black bean aphid is often a pest on shoots.

Sow: mid- to late fall; mid- to late winter **Harvest:** late spring to early summer

Fava bean '*The Sutton*'
Compact and bushy, this fava bean reaches only 18 in (45 cm), so is ideal for small gardens and for sowing under cloches in late winter and on windy sites. It produces abundant small pods packed with juicy white beans.

Sow: midwinter to early spring
Harvest: early to late summer

Fruiting vegetables: tomatoes

Tomato '*Totem*' F1
A dwarf upright bush variety that is the perfect size for patio containers and large window boxes. It crops well outdoors: by midsummer, its trusses are heavy with small, tasty red fruits.

Sow: (indoors) midwinter to mid-spring; (outdoors) early spring to mid-spring **Harvest:** midsummer to mid-fall ♢ ◑ ☼

Tomato '*Tumbler*' F1
Ideal outdoors in hanging baskets or large containers, this bush tomato has stems that trail attractively over the side of a pot. It provides a prolific crop of sweet, red cherry tomatoes.

Sow: (indoors) midwinter to mid-spring; (outdoors) early spring to mid-spring **Harvest:** midsummer to mid-fall ♢ ◑ ☼

Tomato '*Early Bush Cherry*'
Easy to grow and quick to ripen, this bush variety does well outdoors in containers, or in a greenhouse. Its huge numbers of small, round, cherrylike fruits have a sweet flavor.

Sow: (indoors) midwinter to mid- spring; (outdoors) early spring to mid-spring **Harvest:** midsummer to mid-fall ♢ ◑ ☼













Tomato '*Sungold*' F1
Masses of incredibly sweet, orange cherry tomatoes make this a popular variety. It is a cordon tomato, so needs staking and side-shooting. It grows well under glass or outdoors.

Sow: (indoors) midwinter to mid-spring; (outdoors) early spring to mid-spring **Harvest:** midsummer to mid-fall ♢ ◑ ☼

Tomato '*Sweet Olive*' F1
For baby plum tomatoes that grow outdoors, try this reliable cordon variety. The clusters of scarlet fruits have an excellent, intense flavor, and the skins do not split readily. Plants may require some staking.

Sow: early to mid-spring **Harvest:** midsummer to mid-fall ♢ ◑ ☼

Tomato '*Shirley*' F1
This dependable greenhouse variety yields heavy crops of large, rounded, scarlet fruits, even in poor weather conditions. A cordon variety, it requires staking and side-shooting, but has some disease resistance.

Sow: midwinter to early spring **Harvest:** early summer to early fall ♢ ◑ ☼

Tomato '*Tigerella*' F1
Unusual red fruits striped with yellow make this variety stand out, but they also taste delicious and mature early. A cordon tomato that crops well indoors and outside.

Sow: (indoors) midwinter to mid-spring; (outdoors) early spring to mid-spring **Harvest:** midsummer to mid-fall ◊ ◑ ☼

Tomato '*Gardener's Delight*'
Perfect for a sheltered spot outside or a greenhouse, this is an extremely popular cordon tomato variety because of its bumper crops of fine-flavored, large cherry tomatoes.

Sow: (indoors) midwinter to mid-spring; (outdoors) early to mid-spring **Harvest:** midsummer to mid-fall ◊ ◑ ☼

Tomato '*Ferline*' F1
An excellent cordon tomato producing large, rounded, red fruits, with increased blight tolerance. Plants grow well inside or out, and the fruits have a rich flavor.

Sow: (indoors) midwinter to mid-spring; (outdoors) early to mid-spring **Harvest:** midsummer to mid-fall ◊ ◑ ☼













Tomato '*Supersweet 100*' F1
For long trusses of juicy, sugary, scarlet fruits, this is a great variety to try under glass. With good resistance to verticillium wilt, these vigorous cordon plants are easy to grow and yield reliably generous crops.

Sow: midwinter to mid-spring **Harvest:** midsummer to mid-fall ◊ ◑ ☼

Tomato '*Super Marmande*'
This variety has a bushy habit, but benefits from some support. The large fleshy, puckered fruits are bursting with flavor and are a favorite in France. Plants thrive outdoors in warm areas.

Sow: midwinter to mid-spring **Harvest:** midsummer to mid-fall ◊ ◑ ☼

Tomato '*Summer Sweet*' F1
An early plum tomato for a sunny spot outdoors or in a greenhouse, this cordon variety yields plenty of small, tasty, red fruits over a long season. Plants have resistance to fusarium to help ensure a good crop.

Sow: midwinter to mid-spring **Harvest:** midsummer to mid-fall ◊ ◑ ☼

Fruiting vegetables: eggplant, peppers, sweet corn

Eggplant '*Moneymaker*' F1
This is one of the most dependable eggplants in cool climates. The upright plants look good in containers, and while the best long, dark purple fruits are achieved under glass, plants also do well in a sunny outdoor spot.

Sow: early to mid-spring
Harvest: midsummer to early fall

Eggplant '*Black Beauty*'
A prolific variety, producing many glossy, deep purple, oval-shaped fruits. The highest yields are achieved with the protection of a greenhouse. Plants are best tied to supports to help bear the weight of the fruits.

Sow: early to mid-spring
Harvest: midsummer to early fall

Eggplant '*Mohican*'
With its compact bushy habit and immaculate white fruits, this eggplant makes a striking container plant for a sunny patio or greenhouse. Plants reach only 24 in (60 cm). Pick the fruits small to increase the yield.

Sow: early to mid-spring
Harvest: midsummer to early fall













Pepper '*Gypsy*' F1
Good, early crops are reliably produced by this sweet pepper, which performs well under glass. Tapering fruits ripen to bright red from yellow-green and have thick, succulent flesh. Plants are resistant to tobacco mosaic virus.

Sow: early to mid-spring
Harvest: midsummer to mid-fall

Pepper '*Marconi Rosso*'
The elongated fruits of this pepper are best eaten when red, because at this stage they are extremely sweet and ideal for roasting. Plants are high-yielding indoors or in a warm, sunny spot outside.

Sow: early to mid-spring
Harvest: midsummer to mid-fall

Pepper '*Corno di Torro Rosso*'
Delicious, long, thin-walled peppers are sweet once they have turned to purple and red. This early variety appreciates the extra heat in a greenhouse, but crops outdoors in warm areas.

Sow: early to mid-spring
Harvest: midsummer to mid-fall

Pepper '*Hungarian Hot Wax*'
An attractive, compact chili pepper bearing tapering fruits that are sweet and yellow when young, but hot and bright red when mature. The best crops are achieved with the protection of a greenhouse or large cloches.

Sow: early to mid-spring
Harvest: midsummer to mid-fall
💧 ☼

Pepper '*Prairie Fire*'
These tiny, bullet-shaped peppers are extremely fiery and look decorative pointing up from the bushy plants, which reach no more than 8 in (20 cm) tall. Ideal for windowsills or against a sunny wall. Plants crop heavily.

Sow: early to mid-spring
Harvest: midsummer to mid-fall
💧 ☼

Pepper '*Friar's Hat*'
Best grown in a greenhouse, these tall plants produce heavy yields of bizarre peppers shaped like sun hats. Plants need staking, while fruits need a long, hot growing season to ripen and build up a hot chili flavor.

Sow: early to mid-spring
Harvest: midsummer to mid-fall
💧 ☼













Sweet corn '*Butterscotch*' F1
A super-sweet mid-season variety, forming large cobs up to 8 in (20 cm) long that are filled with tender, sugary, butter yellow kernels. Grows vigorously and crops well even in cool weather conditions.

Sow: mid- to late spring
Harvest: late summer to early fall
💧 ☼

Sweet corn '*Indian Summer*'
These spectacular multicolored cobs have sweet-tasting kernels in shades of yellow, cream, red, and purple. Keep the plants separate from other sweet corn varieties to prevent cross-pollination and maintain the colors.

Sow: mid- to late spring
Harvest: late summer to mid-fall
💧 ☼

Sweet corn '*Lark*' F1
This variety consistently produces a high proportion of healthy seedlings from each sowing, and is ideal for beginners. The sweet, tender cobs are delicious when boiled briefly and topped with melted butter.

Sow: mid- to late spring
Harvest: late summer to mid-fall
💧 ☼

Perennial/stem vegetables: asparagus, artichokes, celeriac, celery

Asparagus '*Connover's Colossal*'
A traditional variety that yields a heavy crop of thick green spears early in the season. Buy young crowns and try not to harvest in their first year—just cut a few spears in the second and reap the reward in the third.

Plant: late winter to early spring
Harvest: late spring
☼

Jerusalem artichoke '*Fuseau*'
This relative of the sunflower produces long, smooth tubers, with a flavor similar to globe artichokes, which are usually eaten cooked. Plants may reach 10 ft (3 m) in height, each yielding about 10 tubers.

Plant: late winter to late spring
Harvest: early to late winter
◑ ☼

Globe artichoke '*Green Globe*'
Often difficult to find in stores, but easy to grow, this reliable globe variety has large flowerheads with delicious, tender hearts. Grow from offsets where available.

Sow: late winter to early spring
Plant offsets: late spring to early summer **Harvest:** late spring to early summer ◑ ☼













Celeriac '*Monarch*'
Easier to grow than celery, with a milder flavor, celeriac is delicious raw, steamed, or roasted. This cultivar has unusually smooth skin, making it easier to clean than most, and has fine-textured, creamy flesh.

Sow: early to mid-spring
Harvest: mid- to late fall
◑ ☼

Celery '*Victoria*' F1
The attractive pale green stems of this variety have a particularly good flavor and crispness. There is no need to earth up the stalks to blanch them, and the plants are slow to bolt.

Sow: late winter to mid-spring
Harvest: late summer to mid-fall
◑ ☼

Celery '*Celebrity*' F1
An excellent self-blanching variety that grows equally well outdoors or in a greenhouse. The light green stems have a delicious, strong flavor, and plants resist bolting well.

Sow: late winter to mid-spring.
Harvest: late summer to mid-fall
◑ ☼

Herbs

Parsley '*Plain Leaved 2*'
A fine French parsley, with soft, flat, rich green leaves that have a good, strong flavor. Easily grown as an annual indoors or outside, although parsley is biennial and hardy enough to persist in most gardens.

Sow: early spring to late summer
Harvest: year round

Parsley '*Envy*'
Handsome and vigorous, this variety produces a mass of tightly curled, bright green, full-flavored leaves. Parsley seeds may be slow to germinate, but be sure that the soil is soaked after sowing.

Sow: early spring to late summer
Harvest: year round

Basil '*Sweet Genovese*'
Large-leaved and intensely aromatic, this is the basil to use in Italian dishes. The tender plants will grow in a sunny spot outdoors, but often do best on a bright windowsill or in a greenhouse. Pinch out young leaves regularly.

Sow: early spring to midsummer
Harvest: year round













Basil '*Magic Mountain*'
With its glossy, purple-tinted foliage and tall spikes of lilac flowers, this tender herb makes a pretty garden plant in its own right. The leaves have a delicate aniseed scent, which makes them suitable for Thai cooking.

Sow: early spring to midsummer
Harvest: year round

Thyme '*Silver Posie*'
The tiny gray and cream leaves of this compact and low-growing thyme are intensely fragrant, complementing the flavors of chicken and fish. An evergreen hardy perennial, it has clusters of pink flowers in summer.

Sow: early to late spring
Harvest: year round

Thyme '*Doone Valley*'
The vibrant yellow variegation of this thyme's evergreen foliage, combined with a flush of purple summer flowers, makes it a beautiful plant for a pot or herb garden. The lemon-scented leaves taste good with fish or in stews.

Sow: early to late spring
Harvest: year round

Herbs and sprouting seeds

Oregano (*Origanum vulgare*)
A pungent Mediterranean herb often used in Italian cuisine and reliably perennial in freely draining soil. Its rounded, yellow-green leaves and low-growing habit make it an attractive garden plant, useful for edging paths.

Sow: early to late spring
Harvest: year round

Rosemary (*Rosmarinus officinalis*)
This shrub bears the tough, narrow, strongly scented leaves that combine so well with lamb. As an evergreen, rosemary provides useful structure in the herb or vegetable garden, and can be pruned to maintain its shape.

Sow: early to late spring
Harvest: year round

Fennel (*Foeniculum vulgare*)
Elegant and airy, fennel comes in green and bronze forms and may reach 6 ft (1.8 m) tall. It is a good-looking perennial in ornamental borders, where its aniseed-flavored leaves, and later its seeds, can be harvested as required.

Sow: early to late spring
Harvest: late spring to early fall













Apple mint (*Mentha suaveolens*)
Delicious, but invasive, this mint is best confined to a pot in small gardens. It is perennial and each spring sends up new shoots clothed with soft, furry, sweetly minty leaves, perfect for cooking with new potatoes.

Sow: early to late spring
Harvest: late spring to late summer

Spearmint (*Mentha spicata*)
Spearmint's clean, crisp flavor is ideal for adding to salads, desserts, and drinks. The pointed, deep green leaves are glossy and appealing, but this is also an invasive perennial, so keep its spreading shoots in check.

Sow: early to late spring
Harvest: late spring to early fall

Chives (*Allium schoenoprasum*)
The clumps of these easy-to-grow perennials have spiky leaves topped with purple pompon flowers, making them an excellent path edging. The delicate onion flavor of chives suits soups, salads, and quiches.

Sow: early to late spring
Harvest: at any time

Cilantro '*Cilantro for Leaf*'
A lush, leafy annual, bred to yield several cuts of spicy leaves, rather than seeds. Sow successionally every six weeks to ensure a constant supply and keep plants well watered to stop them from rapidly running to seed.

Sow: mid-spring to early fall
Harvest: early spring to early fall
☼

Common sage (*Salvia officinalis*)
Ornamental, with many culinary uses, this aromatic shrub has pale green leaves covered in an attractive gray down. Encourage bushy growth by pinching out growing tips, but replace old plants every five years.

Sow: mid- to late spring
Harvest: at any time
☼

Lemon grass (*Cymbopogon citratus*)
Tropical and tender, this grass needs to be kept above 45°F (7°C) in winter. The sturdy, citrus-scented stems can be slow to bulk up in cool climates, but form clumps from which stems can be separated and used in Thai dishes.

Sow: mid- to late spring
Harvest: late spring to early fall
☼













Alfalfa
A nutritious, crisp sprout, with a slightly nutty flavor, alfalfa is delicious in salads and sandwiches. Soaking the seeds for eight hours before sprouting helps speed up the process. Sprouts should be ready from trays or jars in 4–5 days.

Sow: at any time
Harvest: at any time

Mung beans
These tiny green beans burst rapidly into life to become the well-known white Chinese bean sprouts, so often included in stir-fries. Soak the beans for 8–12 hours, before sprouting in a jar, tray, or sprouting bag for 2–5 days.

Sow: at any time
Harvest: at any time

Garbanzos
Sprouted garbanzos (chickpeas) are a tasty snack or addition to a salad and require only 2–3 days in a jar, tray, or sprouting bag before they are ready to eat. Soak them in water for 8–12 hours before sprouting, to ensure that the seed coat is softened.

Sow: at any time
Harvest: at any time

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the organic gardener

How to create flower, vegetable, herb and fruit gardens using completely natural techniques



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christine and michael lavelle



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This book is dedicated to Mike Lavelle who would have loved to have seen this book.

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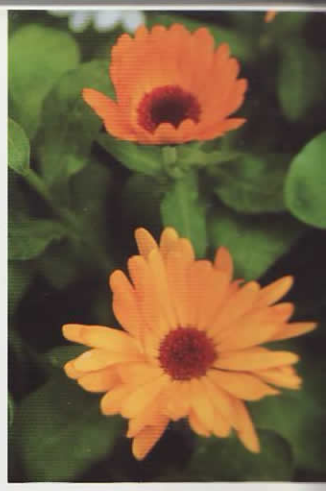
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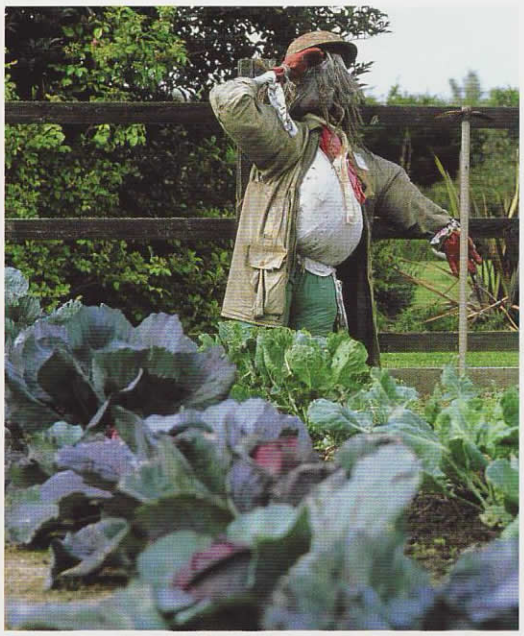
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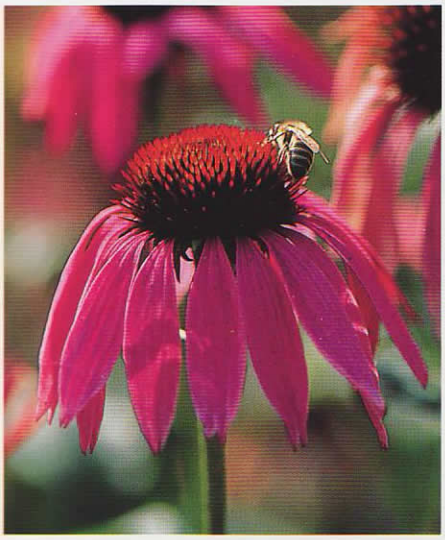




INTRODUCTION

The aim of this book is to show that organic gardening is gardening at its best. The most successful organic gardeners learn that the use of artifical chemicals for short-term gains leads to long-term losses and also that nature makes the best model. Whether you want to grow organic produce for your table, have a dazzling display of summer colour or create a wildlife paradise, the organic garden is for you. Many techniques may already be familiar to you and the change will be less difficult than you think. Going organic may not change the world immediately, but being an organic gardener means that you can make a difference to the wellbeing of the world.

Left: *A well-maintained ornamental garden will reward the keen organic gardener with a wealth of dazzling colour.*



Above: *Organic gardens are highly beneficial to wildlife because they mimic natural environments.*



Above: *The organic garden is the ideal place in which to grow a selection of fresh healthy vegetables.*



Above: *Ornamental plants and flowers are perfectly at home and thrive in a garden that uses organic principles.*

WHAT IS ORGANIC GARDENING?

The term organic means of living origin. When applied to gardening, organic has come to mean the systematic use of techniques that mirror naturally occurring systems. Put simply, it is about finding environmentally friendly ways to cultivate the land, working with rather than against nature. Organic gardening refers not just to a system of techniques, however, but also to a whole philosophy of life.



Above: *The organic garden uses a range of natural materials, including by-products such as chicken manure.*

THE ORIGINS OF ORGANIC GARDENING

From the point of view of gardening, the "modern" organic movement began in the late1940s as a reaction to the increased use of pesticides and synthetic fertilizers in the years after the Second World War. In many respects, however, the principles of organic gardening have been practised for centuries. Ancient writers, among them Pliny and Virgil, commented on the importance of "good husbandry to the health of the land". Thomas Tusser, in his classic work of 1580 entitled *Five Hundred Points of Good Husbandry*, recommends crop rotation to maintain good health. The 17th-century English garden writer John Evelyn begins his *Kalendarium Hortense* with a section describing how to enrich the ground in mid-winter with "horse and sheeps dung especially, that you may have some of two years preparation".



Above: *Many of the plants that benefit wildlife also make showy and decorative additions to beds and borders.*

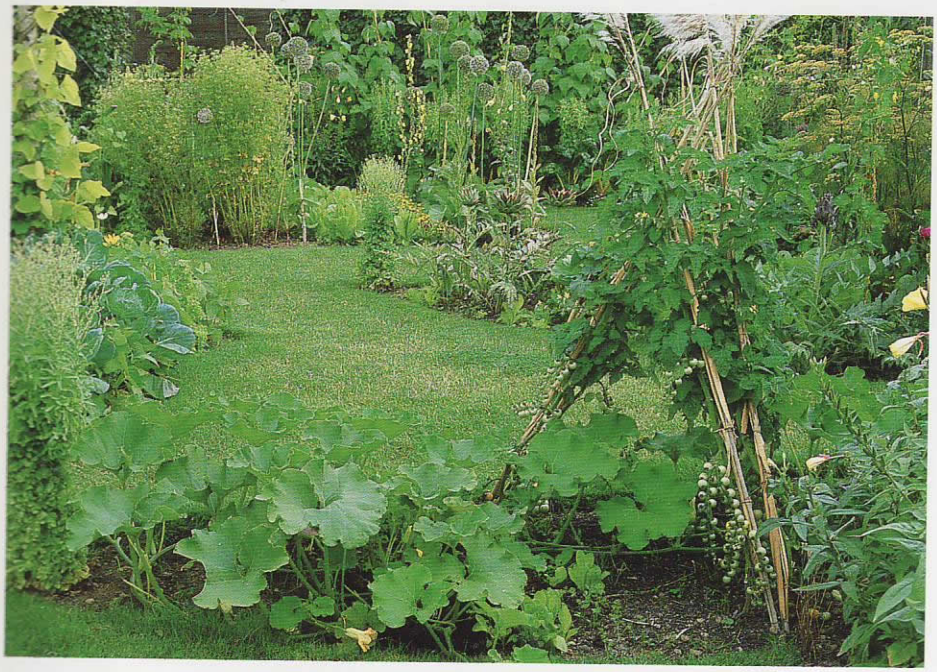
ORGANIC GARDENING IN THE 21ST CENTURY

Much of the current interest in organic gardening began in the 1960s, when there was increasing concern about the growing levels of environmental damage caused by pesticides and other agrochemicals. If they were causing so much damage to the natural world, then surely they must ultimately affect human beings?

The organic approach aims to reduce the effects that our gardens, farms and cities have upon the wider natural environment. Activities such as recycling, using sustainably produced materials and avoiding pesticides and other harmful agrochemicals all help in this. Organic gardening is often described as being a more natural way to garden. This can make it appear to be somehow revolutionary. In many ways, however, organic gardening could be said to be counter-revolutionary. It aims to avoid artificial inputs and gains. Instead it draws from a vast resource of wisdom and experience amassed over 10,000 years. Much of the so-called conventional wisdom is, in fact, very recent. We only have to look back as far as our grandparents to see that they were naturally organic gardeners. Organic gardening then is the marriage of good horticultural practice to an awareness of our impact upon our surroundings.

IS IT POSSIBLE TO BE WHOLLY ORGANIC?

The short answer to this would probably have to be ... with great difficulty. But the purpose of this book is not to promote difficulty or set unattainable goals. The aim should always be to aspire to the ideal solution. Almost all of us face compromise on a daily basis and understand that practicalities outweigh personal ideals. With perseverance and practice, however, it is possible to become less compromised in the confines of your own garden. Simple planning and the observance of good

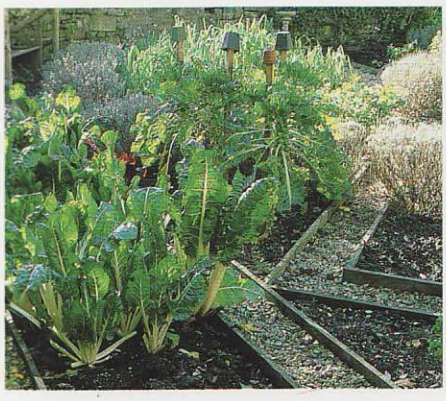


Left: *Organic gardens can be beautifully designed and can include a mixture of ornamental and edible plants.*



Above: *A well-designed and properly maintained organic garden can be both attractive and productive.*

gardening practice can steadily improve your organic credentials and, with time, a natural balance will be established in your garden. Ultimately, the aim of all organic gardeners, be they landscaping a city garden, tending a country estate or growing home-produced vegetables, is to make choices appropriate to their situation. It is better to move a few steps towards the organic way than to ignore it completely.



Above: *Vegetables need not be planted in rows. Here, the beds are arranged in an attractive geometric pattern.*

ORGANIC STANDARDS

Organic standards are set out to explain the requirements that farmers, growers, processors and others must meet in order for their products or services to be marketed as organic. The standards can be extensive and cover a wide range of farming, growing and food manufacturing practices.

Are organic standards the same worldwide? No. Different countries may stipulate their own standards. IFOAM is the International Federation of Organic Agricultural Movements that represents the worldwide body of organic agriculture and provides a platform for the global exchange of information and co-operation.

Are any chemicals allowed in organic production? Yes. In line with the legal framework of the country, a very limited number of chemicals are allowed on a restricted basis. Organic standards do not allow the use of artificial herbicides or fungicides. By comparison, in non-organic farming as many as 450 chemicals can be routinely used.

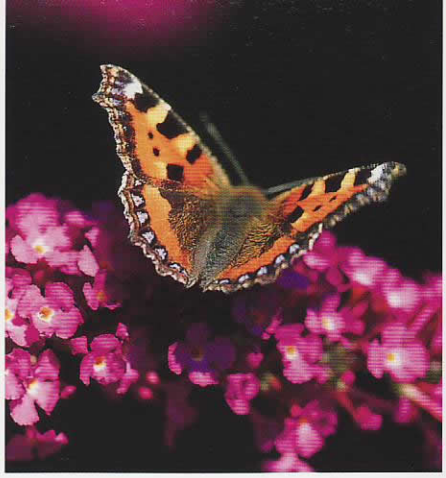
If organic gardening severely restricts the use of artificial chemical fertilizers and pesticides, then how do I keep my garden healthy? Organic gardeners rely on developing a healthy fertile soil and growing a mixture of crops. By following these basic practices, organic gardeners work in harmony with nature and aim to achieve a healthy natural balance within their gardens.

Do I have to achieve any standards to become organic? No. Commercial standards are very strict and not necessarily easy to achieve for the amateur. Everyone must make choices appropriate to their own situation.

Is the organic movement just concerned with growing food? No. Going organic is not just about organic food – it should become a way of life. Today, organic wood, clothing, gardening products and even restaurants can all be found. This means that other areas of your life can be organic as well as your garden. It does not always mean completely changing your life, but it can change lives.

WHY GO ORGANIC?

This commonly asked question is easy to answer. The primary reason to embrace the organic approach is health. This means the well-being of the individual as well as the health of the environment. Many pesticides can accumulate over time, both in our own bodies and in the wider environment, a poisonous legacy that can persist for decades. Organic gardening seeks to redress this damage by working with and encouraging nature. It is a long-term investment in the health and wellbeing of us all.



Above: *Butterflies are just one of the many different types of wildlife that can benefit from a pesticide-free garden.*

GREEN CUISINE

Hardly a day seems to go by without some new revelation about the benefits or detrimental effects of some food or other. Recent concerns about the "goodness" of the things that we eat have been a major incentive to supermarkets to supply a growing demand for organic produce. There can be little that equals the satisfaction to be derived from eating home-produced food, gathered fresh from the garden. What better than garden-fresh vegetables that are produced naturally and cleanly?

A GREENER, SAFER GARDEN

Although we think of our gardens as places of safe retreat we have used a cocktail of pesticides and agrochemicals on them that has stripped them of their natural diversity. Many of these poisons no longer control the beasts that they were intended to. All that suffers in this noxious onslaught is the garden, its wild occupants and ultimately the plants. This cycle of pesticide use eventually turns your personal paradise into a potential health hazard.

HELPING THE ENVIRONMENT

For many of us it can seem that there is little that we can do to change the degradation of our environment. But the truth is that the actions of all of us have both positive and negative impacts upon the land. If every individual reduces his or her own negative impact upon the environment, then collectively we can make a difference. By changing the way you garden to a more organic way, you can begin the healing process, literally in your own backyard.

PROTECTING AND ENCOURAGING WILDLIFE

Be it a bird on a feeder or brightly coloured butterflies on a flower, most of us enjoy seeing visitors from the wild in our gardens. But many of the unsung heroes of our gardens – the insects, worms, amphibians and mammals that crawl, slither and scurry out of sight – are equally important and may even be the reason why some of the larger visitors come. Organic gardening helps many of these and promotes a balance of wildlife that is both interesting and beautiful to look at.

SO WHAT IF I DO NOT GO ORGANIC?

While the intention of this book is not to dwell upon negative points, the cost of not adopting an organic approach may be seen all around us. This is most frequently noticed as fields and open spaces bereft of butterflies, bees, birds and other wildlife with very little diversity of plant species. It is unthinkable that we could hand this planet to successive generations in a denuded and impoverished state. Perhaps a garden free of "bugs" may sound attractive to some, but the long-term cost to the environment may be felt for generations and in the worst case may even be permanent.



Above: *Organic flower gardens, with their wide range of wildlife-friendly plants, can provide a balanced habitat for birds and insects that is diverse, interesting and beautiful to look at.*



Above: *Imaginative planting designs can result in beautiful contrasts of flowers and foliage, while also providing a wealth of flavourful, home-grown food for your table.*

IT'S A SOLUTION AND IT'S FUN!

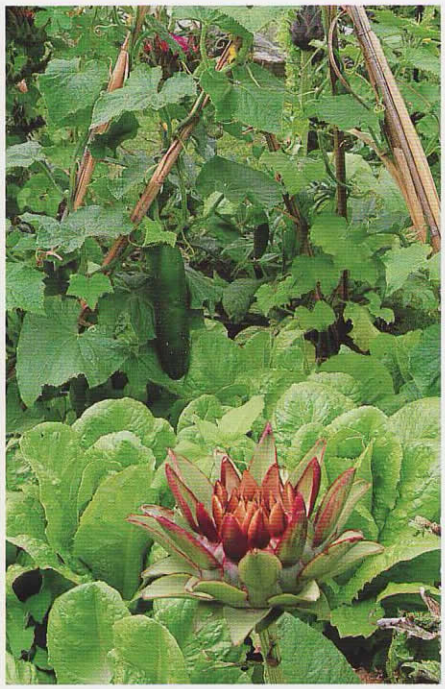
Organic gardening is not the solution to all humankind's problems. However, it is a positive and valuable step that you as an individual can take. What's more, you can contribute positively to the wellbeing of your surroundings and to that of your wider environment by doing something that is also fun and rewarding.

WILL "GOING ORGANIC" MEAN THAT MY WHOLE LIFESTYLE HAS TO CHANGE?

Organic gardening is often presented as part of a more general "organic movement". This movement owes its origins to a range of social philosophies, some of which are more fundamentalist than others. The aim of organic gardening is to change the way that you garden and not your whole life. People frequently get confused about the meaning of words that are used as part of the wider organic movement. Four of these terms are explained below. Of these, three describe a whole philosophy that affects practitioners far beyond the confines of their own gardens. An understanding of the philosophies of others can help inspire your own lifestyle changes and all have their own points of interest. In the end, however, it is a matter of choice for you alone and it is best to decide just how organic you (and your family) wish to be.

Biodiversity literally means "the variety of life". It includes all the different plant, animal, fungus and microscopic species in the world. It also considers the genes they contain and the ecosystems of which they form a part. Biodiversity has been seen as the total complexity of all life, including not only the great variety of organisms but also their varying behaviour and interactions. An organic garden aims to maximize all these many different things which are vital to every part of the garden, but especially important when considering the soil. Soil biodiversity is the "lifeblood" of the organic garden and demands investment in order to yield a return.

Biodynamics is described by its practitioners as a science of life forces, recognizing the basic principles at work in nature and taking into account how our actions can bring balance and healing to the world. It is based upon the work of Rudolf Steiner and is said to offer an account of the spiritual history of the Earth as a living being. Its enthusiasts advocate a broadening of personal perspective that includes an understanding of cosmic rhythms, natural healing, a respect for life forces and ultimately a shift away from centralized economic strategies.



Above: *The foliage and form of many types of vegetables can provide striking contrasts in the vegetable garden.*

Permaculture is a concept that was originally developed in the 1970s by Australians Bill Mollinson and David Holgreen. It was conceived as a response to increasing concerns over the deteriorating natural environment. They attempted to answer the question "how do we, as the human species, sustain ourselves and provide for the needs of the environment for an indefinite period of time?". The answer to this question is the basis for creating a permanent culture (Perma-Culture). This philosophy aims to unite practical, ecological design philosophies by incorporating natural systems and materials into human habitats. Permaculture rejects short-term gains in favour of long-term stability for the environment and those who live in it.

Self-sufficiency is an ideal rather than a reality for most that attempt it, as modern living usually dictates some degree of trade, even if it is limited. Advocates of self-sufficiency aim to produce everything that they need in order to support themselves. The only imports are those that cannot be produced by an individual.

REASONS FOR GOING ORGANIC

Below are just a few of the positive benefits that organic gardening may bring to you and your environment.

Human impact on the earth Organic systems reduce dependence on non-renewable resources. The world has an increasing population, but many of our resources are in limited supply. Using renewable resources helps to secure our common future.

Traditional methods with modern techniques Organic systems rely on a modern, scientific understanding of ecology and soil science. They also depend on traditional methods of crop rotation to ensure soil fertility as well as weed and pest control.

Local solutions to global problems The organic movement encourages individuals to act on a local level, while thinking about how this affects the world.

Best for biodiversity Organic growing is friendlier to the environment, so there is a greater diversity of birds, butterflies and plants in organic gardens.

Minimize your waste We produce a huge amount of waste, including packaging and kitchen and garden waste. Recycling and waste reduction are key issues for organic living.

Mimicking natural systems Organic gardening uses nature as its model and, by working in harmony with nature, aims to achieve a natural balance. By maintaining this equilibrium, organic gardens become very stable entities.

A more interesting garden Organic production is more sustainable and friendlier to the environment. By becoming involved in the whole natural cycle, you will gain greater satisfaction from your own personal Eden.

We are what we eat ... Organic systems recognize that our health is connected to the quality of our food and, ultimately, to the health of the soil.

UNDERSTANDING YOUR GARDEN

Plants, like all living things, flourish when given the right conditions. Certain plants will only thrive in a hot, sunny and dry garden, for example, while others may need cool, moist and shady conditions to prosper. If you are to have healthy plants, you need to choose those that are best suited to your garden and this means understanding exactly what conditions prevail and taking into account a range of environmental factors.



Above: *A hot, sunny spot is ideal for growing pretty summer flowers such as argyranthemums and verbenas.*

CLIMATE

The climate causes a variety of responses, depending upon the plant's location, its stage of maturity, the length of exposure and the intensity of the type of weather. Climate may have a dramatic effect on plant growth and development, especially when extreme weather conditions prevail.

TEMPERATURE

All plant species have their own maximum and minimum temperature tolerances, beyond which the life processes of the plant cease. As a general rule, the maximum temperature that most plants can tolerate is around 35°C (95°F), while the minimum is highly variable. The air and soil temperatures are also crucial in influencing dormancy within plants and this, in turn, largely dictates the length of the growing season.

Air temperature is affected by the degree of energy received from the sun. A sheltered site that benefits from the warming effects of the sun may be used for growing plants that are indigenous to warmer climates.

Soil temperature influences a plant's root development and the rate at which water and nutrients can be absorbed. Sandy soils warm up quicker and earlier in the season than clay soils, mainly because they are relatively free draining and do not hold as much water. Sites that receive a lot of sun, or with a slight incline towards it, will also warm up quicker than shady ones.

WATER

This is the major constituent of all plants. In most gardens, rainfall is the principal source of water for plants and it can be lost through evaporation or surface run-off, although much of it is soaked up by soil particles. This water may then be absorbed by the root hairs of the plant. A steady supply of water is essential for the plant to sustain itself and for optimum growth.

Water may also be held in the air and is referred to as humidity. The amount of water vapour in the atmosphere at any one time is referred to as the relative humidity and is measured as a percentage of the saturation point (100 per cent humidity). In areas that receive heavy rainfall, relative humidity is also higher. Many plants, such as ferns and mosses, thrive in such conditions. But high relative humidity can have undesirable effects on plants, often encouraging disease.

Waterlogging refers to the build-up of water that may occur in badly drained soil with poor structure. The roots of plants that are not adapted to these conditions will suffer and probably die through asphyxiation.



Left: *A bog garden provides ideal conditions for a range of decorative moisture-loving plants.*

Right: *Blossom is both pretty and essential for good fruit-set. A sheltered site will also encourage pollinating insects.*

LIGHT LEVELS

Sunlight enables photosynthesis (the method by which plant food is made) to occur. As a result, it is vital to new growth as well as sustaining existing growth. Seasonal changes in light levels may also trigger different stages in the plants' development.

AIR CIRCULATION

Even moderate winds can increase a plant's transpiration rate. However, a light wind can also have beneficial effects, providing relief from extreme heat and cooling the foliage. It will also "change the air" around the plant and thus help to alleviate a stagnant atmosphere that could promote disease.

ASSESSING THE CLIMATE

A range of climatic information is generally available for your local region. Weather forecasts are an obvious source, but long-term records are sometimes available. From these you should be able to get a picture of the average rainfall, snow, frosty days, wind direction and monthly temperatures.



A TYPICAL GARDEN AND ITS MICROCLIMATES

Even a small garden can contain a wide variety of microclimates, ranging from cool, shady corners to hot, dry areas. A proper assessment of the growing conditions that prevail in your garden allows you to choose the right plants for the right place.



A GARDEN'S MICROCLIMATE

The prevailing weather conditions in confined or discrete areas are termed the microclimate. For example, there will be a range of environments within a small domestic garden that may be very different from those weather conditions prevailing elsewhere in the locality. Observe what is going on in your own garden and keep a careful record of the position and influence of the following features.

Walls, hedges and fences may cause wind turbulence and dryness, depending upon their height and density. They may cause cold air to build up on sloping sites by preventing it from "draining away" downwards. This can create frost pockets that may have a crucial effect on the type and range of plants that may be grown.

Shadow projections from permanent features, such as buildings, walls, hedges and large trees, may create a range of dense shadow resulting in dark, dry and often cool conditions that will only suit certain plant species.

Hot spots may occur with aspects that are subject to high and prolonged levels of sunlight. Plants may struggle in the dryness created by such strong sunlight.

Damp areas may be anticipated where the ground is low-lying, especially on very heavy soils. During heavy rainfall you should also note the direction of water flow, including where necessary the route taken by excess surface water, which may in extreme cases be the cause of soil erosion.

Soil type and pH play an important role in the ability of a site to support particular plant species. The relative acidity or alkalinity can affect the availability of certain essential nutrients, leading to either shortage or toxicity in plants not ideally suited to the pH of a soil. It is always better to choose plants that thrive in the particular pH of a soil. Attempts to alter the pH by acidifying or adding lime are rarely satisfactory and neither are long-term solutions.

Existing habitat types on and around the garden indicate what plants are likely to thrive. Notes should be made on the range of species and the likely wildlife value.

The garden topography (the shape and aspect of the land) may also affect what you are able to do. If a garden slopes toward the direction of the midday sun, for instance, it will be warmer than a flat site. Sloping or uneven gardens have their own problems, particularly if you wish to site a greenhouse.

RIGHT PLANT, RIGHT PLACE

Once you have assessed your garden environment, you will be able to choose the right plants for your site. Every garden has its own unique set of advantages and limitations, and these take time to evaluate, so trial and error is ultimately the most reliable method.



Right: *A shady corner of the garden provides the perfect place for shade lovers such as these foxgloves (*Digitalis*).*

THE ORGANIC CYCLE

Plants produce their own food using carbon dioxide from the air, water from the soil and energy from the sun in a process known as photosynthesis. The energy in this sugar powers all the growth, development and life-giving processes within the plant. Plants must also produce a range of other substances, including proteins, fats, oils and cellulose, for which they need nutrients such as nitrogen, phosphorus, and potassium. These are almost always taken up through the roots.



Above: *Plant leaves are remarkable structures because they are the factories in which a plant makes its food.*

WHAT PLANTS NEED

In natural systems, nitrogen, phosphorus and potassium are repeatedly taken up by the plant, used and returned to the soil when the plant dies, drops its leaves or is eaten by an animal. This process is known as nutrient cycling. Plant nutrients are covered in more depth later. For now we need only look at three of the most important cycles: water, carbon and nitrogen.

THE WATER CYCLE

The movement and endless recycling of water between the atmosphere, the surface of the land and under the soil is called the water cycle and is driven by the energy of the sun and the force of gravity.

Water vapour in the atmosphere condenses into clouds, which fall as snow, rain, sleet or hail. This water may be taken up by plants, stored in lakes, enter the soil or flow over the surface in streams. The sun causes water to evaporate back into the atmosphere, or gravity may pull it down through the pores of the soil to be stored as slow-moving ground water. Water can also return to the atmosphere indirectly through plants' leaves – a process known as transpiration – this being highest during periods of high temperatures, wind, dry air and sunshine.



Above: *Plants rely on water, taken up through the roots, to support their life processes and facilitate growth.*

THE CARBON CYCLE

The movement of carbon, in its many forms, between the total living content of the earth, the atmosphere, oceans, and the rocks and soils covering the surface, is termed the carbon cycle. It is complex and far reaching. The same carbon atoms in your body today have been used in countless other molecules since time began. Plants absorb carbon dioxide from the atmosphere during photosynthesis (food production) and release it back into the atmosphere during respiration (food use). This process is the great natural recycler of carbon atoms.



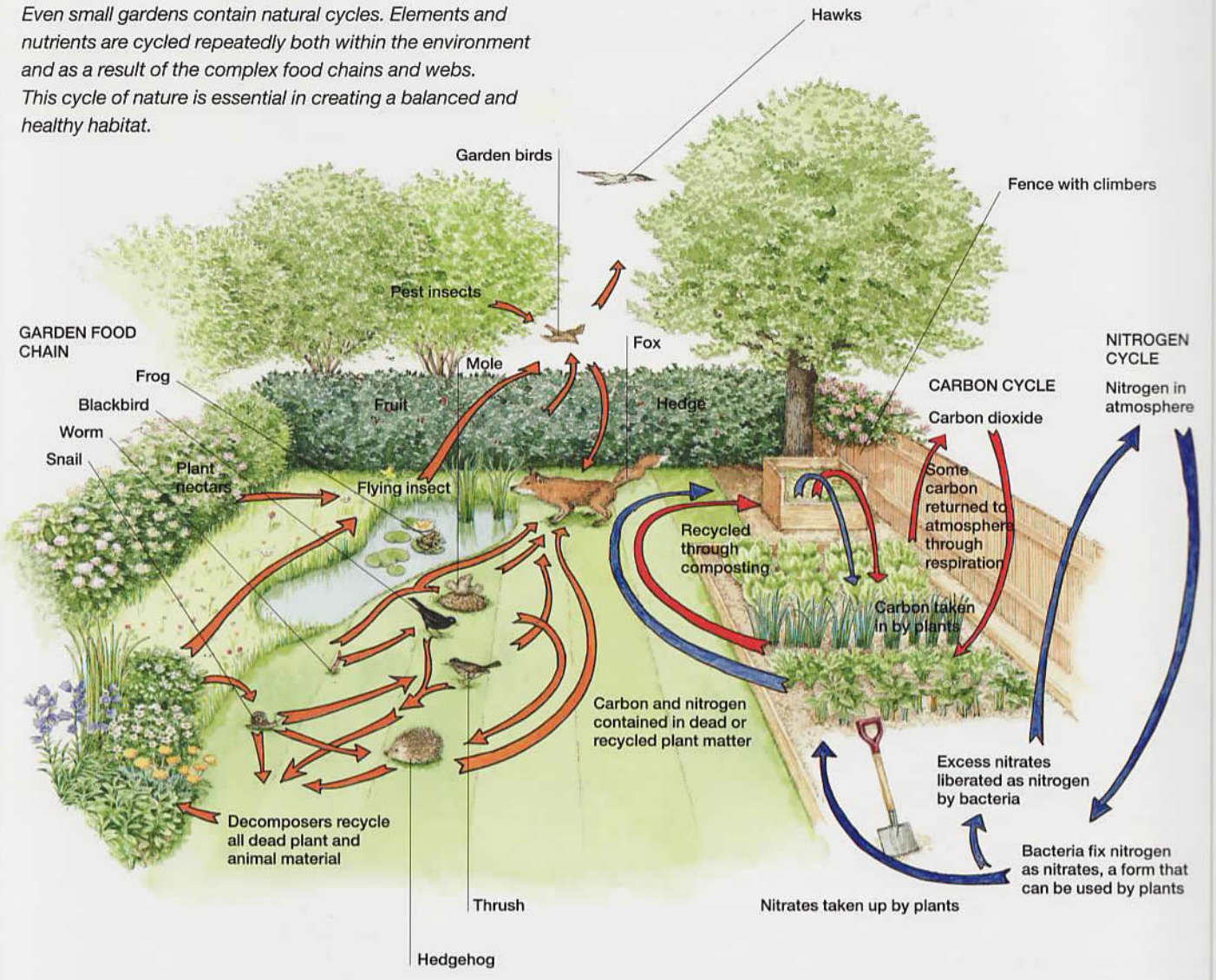
Right: *Left to develop naturally, grassland will become a rich and diverse habitat for a wealth of both plants and wildlife.*

THE NITROGEN CYCLE

Nitrogen is used by living organisms to produce a number of complex organic molecules such as amino acids, proteins and nucleic acids, the "building blocks" of life. The largest store of nitrogen is in the atmosphere, where it exists as a gas. This store is about one million times larger than the total nitrogen contained in living organisms.

NUTRIENT CYCLES IN A TYPICAL GARDEN

Even small gardens contain natural cycles. Elements and nutrients are cycled repeatedly both within the environment and as a result of the complex food chains and webs. This cycle of nature is essential in creating a balanced and healthy habitat.



Despite its abundance in the atmosphere, plants can only take up nitrogen in two solid forms: ammonium and nitrate. Most plants fulfil their needs using nitrate from the soil. Ammonium is used less frequently because it is toxic in large concentrations. Most ecosystems have nitrogen stored in living and dead organic matter, which re-enters the cycle via decomposition. Decomposers in the soil, such as bacteria and fungi, chemically modify the nitrogen found in this organic matter.

Almost all of the nitrogen found in any terrestrial ecosystem originally came from the atmosphere and is biochemically converted ("fixed") into a useful form within the soil by specialized bacteria. Members of the bean family (legumes) and some other kinds of plants form relationships with nitrogen-fixing bacteria. In exchange for nitrogen, the bacteria receive food from the plants and special root structures (nodules) that provide protection.

WHAT ARE ECOSYSTEMS?

Short for ecological systems, ecosystems are communities of plants and animals that consist of a given habitat (the place where an organism lives) and its community (all the plants and animals that live in it). Any group of living and non-living things interacting with each other (including those found in gardens) can be considered an ecosystem.

The chemical materials that are extracted from the environment and changed into living tissue by plants and animals are continually recycled within the ecosystem. These nutrient cycles are at their most efficient when an ecosystem has a good diversity of species. Such diversity tends to make a community stable and self-perpetuating.

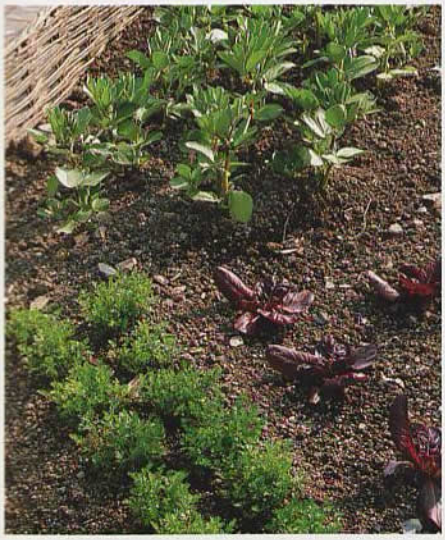
FOOD CHAINS AND WEBS

The energy necessary for life reaches the earth as sunlight. This is made into food and stored in plants. Animals acquire some of the stored energy by eating the plants or by eating other plant-eating animals. Such sequences, called food chains, overlap at many points, forming food webs which show "who eats whom" in an ecosystem. If one animal or plant is affected, then the entire food web can be changed.

SOIL AND SOIL MANAGEMENT

Soil is the most precious resource in your garden. Some inherit a well-tended soil, while others, particularly those moving into new homes, inherit a rubble-filled mass. However, any soil can be improved through time and effort. If you regard your soil as a living entity, you will see that essential plant nutrients are cycled by a microscopic army of inhabitants and larger worms, insects and grubs. All these creatures need air, moisture and food. Using manure, garden compost and other sources of organic matter is the key to sustaining this soil life and keeping the soil healthy.

Left: *The key to developing a successful organic garden lies in the careful management of the soil.*



Above: *Newly planted crops must be kept weed free so that water and nutrients are freely available.*



Above: *Companion plants can help to protect crops naturally from pests, thus avoiding damage to the soil ecology.*



Above: *Crops that are grown in rows must be rotated on a regular basis in order to avoid soil-borne pests and diseases.*

TYPES OF SOIL

Soil is probably the most important constituent of any organic garden because it is vital for successful plant growth. Understanding your soil and knowing how this can help you to create a healthy, fertile growing environment for your plants should be a priority. The starting point in this process is an understanding of the different soil types and how they affect the plants you can grow. Once you understand the soil in your own garden, then you will be able to create a successful organic garden.



Above: *All soil types benefit greatly from the addition of organic matter such as this green manure.*

WHAT ARE SOILS MADE OF?

Both natural soils and some potting mixes for container-grown plants usually have five main components. These are mineral particles (the inorganic fraction), organic matter (the remains of living organisms), water (the "soil solution"), air (which fills the spaces between solid particles that are not filled with water) and living organisms. The proportions of these components vary widely according to the soil type, or the growing medium.

The proportions of water, air and organic matter can be readily changed by soil cultivation and other horticultural practices. A good topsoil will continuously supply plant roots with water, air and nutrients. Subsoil (the largely inert soil layer that lies beneath the thin layer of "living" topsoil) has less organic matter than topsoil. Plant growth will suffer when the proportions of water and air in the medium are out of balance. Too much air will have the same effect upon plant roots as a drought, whereas too much water causes waterlogging. Growth will also suffer if nutrient levels are too low, too high or if there is an imbalance in supply between different nutrients. In addition, soil that is too compacted for roots to grow will also adversely affect growth.

SAND AND SILT

Sandy and silty soils originate from river deposits, windblown sediments or from the erosion of sandstone outcrops. Their general properties are that they do not provide or retain plant nutrients; they are not cohesive and therefore possess a weak structure; and in most cases they are free draining.

Silts, unless well structured, will be waterlogged. Sand, on the other hand, is naturally free draining. The structure and texture of sandy soils means that they are only able to hold a very small reserve of water. Organic matter can improve the available water content but the real trick in avoiding drought-stress lies in ensuring that plants root deeply into the soil. Nutrient shortage can also be a problem on sandy soils which have a tendency to become acidic over time. Liming and the regular addition of organic matter will help alleviate these problems.

Sandy soils do have the advantage of "warming up" quickly in spring due to their lower water content and are easier to work early in the year. This means that you can grow a wider range of plants in a sandy soil. Planting or transplanting is also easier in the autumn.

Organic material is broken down very quickly in sandy soils due to good aeration and a temperature that favours rapid bacterial action. Many light soils naturally have less than two per cent organic matter and it is vital that organic matter be added regularly to sustain healthy plant growth.

COMMON TYPES OF SOIL



Sand A free-draining soil that is quick to warm up, but hungry and thirsty.
Silt River deposits can be sticky, but not as sticky as clay. Rich and easy to work.
Clay A heavy soil that is often difficult to work. Slow to warm up, but fairly rich.
Loam A moisture-retentive soil that warms up quickly and works perfectly.

PLANTS SUITABLE FOR DIFFERENT SOIL TYPES

Many plants have a type of soil in which they grow best. The list below gives a few examples of the soil preferences of some common species.

Plants suitable for acid soils
Rhododendron (all species)
Camellia (all cultivars)

Plants suitable for alkaline soils
Butterfly bush (*Buddleja* spp.)
Sage (*Salvia*)

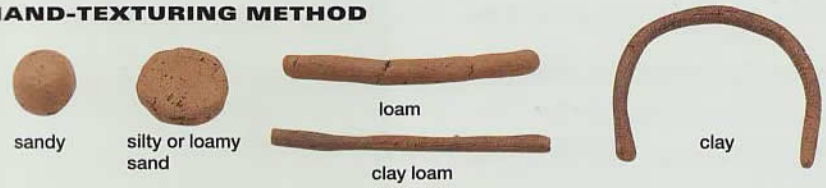
Plants suitable for hot dry soils in sun
Yucca (all species)
Broom (*Cytisus*)
Lavender (*Lavandula*)

Plants suitable for damp or wet soils
Willow (*Salix*)
Dogwood (*Cornus*)
Plantain lily (*Hosta*)

Plants suitable for heavy clay
Weigela (all cultivars)
Crocosmia (all cultivars)
Daffodil (*Narcissus*)

Plants suitable for dry shaded soils
Flowering currant (*Ribes sanguineum*)
Pachysandra terminalis
Elephant's ear (*Bergenia cordifolia*)

HAND-TEXTURING METHOD



Finding out what type of soil you have is easy and does not require any specialist equipment. This test is ultimately a matter of judgement and will only give you a relative picture of the sort of soil you have. However, it is surprisingly accurate. Simply take a small amount of soil – about a teaspoonful will do – in the palm of your hand. Moisten with a little water (not too much but enough to make it just workable). Once moistened, try to form the soil into one of the shapes shown above.

1 Begin by forming a ball. If it stays together, then proceed to the next shape. If it does not form a ball, then you have a sandy soil.
2 If you can flatten the ball without it breaking up, then you have a silty sand or a loamy sand.
3 If you can roll the flattened ball into a thick sausage shape, then you have a loam.
4 A soil that can be rolled into a thin "sausage" is a clay loam.
5 If you can bend the soil into a horseshoe or ring shape, then you have a clay soil.



Above: *Plants such as alliums and eryngiums like well-drained soil and so will thrive together in the same site.*

CLAY

The particles found in clay are extremely small and are able to interact with, and directly affect, the chemistry of the soil. The individual clay particles are so tiny that they are actually bonded together by electrical charges which produce the characteristic plasticity of this type of soil. Clay is both water retentive and rich in nutrients. It has few pore spaces and those that are there have a tendency to become waterlogged. Clay is prone to swelling when waterlogged and shrinkage when dry. As a result, clays heave (swell outward and upward) when wet and crack when dry. They can also be subject to frost action which causes an increase in tiny, almost microscopic, airspaces (micro pores). Pure clay soils are rare, although some soils may be very rich in clay. They have the potential to be extremely fertile soils if they are well managed.

LOAMS

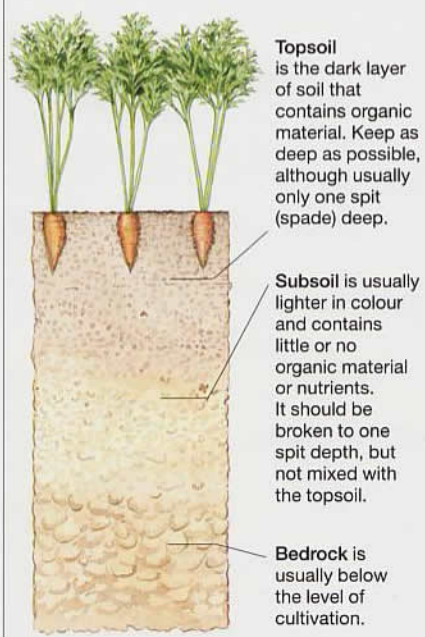
Loams are a mixture of sand, silt and clay that results in a blend of the characteristics of each constituent part. They are usually characterized by their clay content. Heavy loams are about 24–30% clay, whereas light loams contain about 12–18% clay. Heavy loams behave and should be treated like clay soils. Light loams should be treated like sandy soils. Medium loams are potentially the ideal mixture, exhibiting the advantages of both heavy and light soils without many of the disadvantages of either.

HUMUS

This is a stable form of partially decomposed plant material that gives topsoil its characteristically dark colour. Humus has a high nutrient-reserve potential (2½ x better than clay), retains water, increases the friability (suitability for cultivation) of heavy soils and its darker colour encourages soils to warm up more rapidly.

SOIL PROFILE

A typical soil profile usually consists of three main elements: an upper layer of dark, fertile topsoil; a middle layer of lighter, infertile subsoil; and a lower layer of bedrock, which ranges from a few to hundreds of metres (yards) deep.



MANAGING YOUR SOIL

Any soil has the potential to be a fertile growing medium in which plants will thrive if it is managed correctly.

Management of light/sandy soils

- Maintain levels of organic matter.
- Lime when required. (N.B. It is often easier to select species tolerant of the site conditions in the long term.)
- Fertilize well as light soils are usually infertile. (N.B. Some exotic and native plant species actually thrive under relatively poor nutrient conditions.)
- Irrigate frequently in the first year after planting, less so once deeper roots are established.

Management of clay soils

- Drainage is essential.
- Maintain lime status.
- Maintain levels of organic matter and fertilize when needed.
- Wise cultivation is needed to conserve winter or summer tilth produced by natural weathering, i.e. cracking due to wetting/drying cycle and breakdown by frost action.

SOIL STRUCTURE

Soils are made up of mineral and rock particles that give them their natural properties. The character of the mineral fraction cannot be changed but the way that these building blocks are organized within the soil can. Creating and maintaining soil structure is a key aspect of maintaining the fertility of the soil and supporting healthy plant growth. Even the most difficult soils can be modified to create a fertile growing medium for plants.



Above: *Even "difficult" soils can be transformed into a good growing medium by careful cultivation.*

WHAT IS MEANT BY SOIL STRUCTURE?

Soil structure is quite simply the way soils are organized. To use a simple analogy: if we see the soil particles (sand, silt or clay – the mineral fraction) as the building materials – like the bricks and mortar of a house, for instance – then the structure is the architecture. The building materials themselves cannot be altered, but the architecture can vary considerably from home to home. This is the key. It is possible to improve a soil's structure even if the mineral fraction remains unchanged. It is perfectly feasible to have a well-structured clay soil for instance. It all depends upon how well you manage it.

WHY IS SOIL STRUCTURE IMPORTANT FOR PLANT GROWTH?

In order to survive, plant roots need water, nutrients and air. Plant roots breathe in the soil, taking in oxygen and expelling carbon dioxide. A poorly structured soil may have too little airspace. This can have two negative effects. Fresh air (containing oxygen) may not be able to penetrate the soil very easily and the soil will tend to become waterlogged following rain. Waterlogging will also reduce the air available in the soil.

Below: *A rotavator is a useful and labour-reducing method of breaking up the soil to prepare it for planting.*



Structure is therefore very important in terms of maintaining the health of plant roots. Plant shoot development is directly linked to root health. A healthy root system ensures healthy shoots and will ultimately result in better growth and crop yields.

HOW DOES SOIL STRUCTURE DEVELOP IN NATURAL SYSTEMS?

Soil structure naturally develops in soils through the effect of weather cycles. Wetting causes soils to swell while drying causes shrinkage. This naturally causes soils to crack. The action of freezing and thawing is also important on clay soils in areas where frosts occur. They form particles known commonly as crumbs. The "crumb structure" of any soil develops over time and is important in terms of allowing the free passage of water through the soil and air that must be able to move in and out of the soil. In this way soils do not become habitually waterlogged and natural nutrient cycles – oxygen, carbon and nitrogen, for example – are not impeded. Plant roots and soil organisms, such as worms, naturally help to maintain soil structure, as does the natural addition of decaying plant material each autumn.

HOW TO ALTER SOIL STRUCTURE

Humans have learned over time that even an infertile area can be worked – and the structure of the soil improved – by cultivation. This is covered in more detail later but it is essential to understand now that cultivation is a way of rapidly accelerating the natural cycles that promote good structure. Digging and breaking down "clods" helps to introduce air and creates new pores in the soil. Adding organic matter helps to maintain these pore spaces, retains moisture (in dry soils) and encourages the action of soil-dwelling creatures such as worms. No-dig



Above: *If you need to work on wet soil, work from a plank of wood to ensure the soil is not compacted and its structure destroyed.*

systems aim to harness this natural cycle more closely, but the goal is the same – a rich, fertile and well-structured soil.

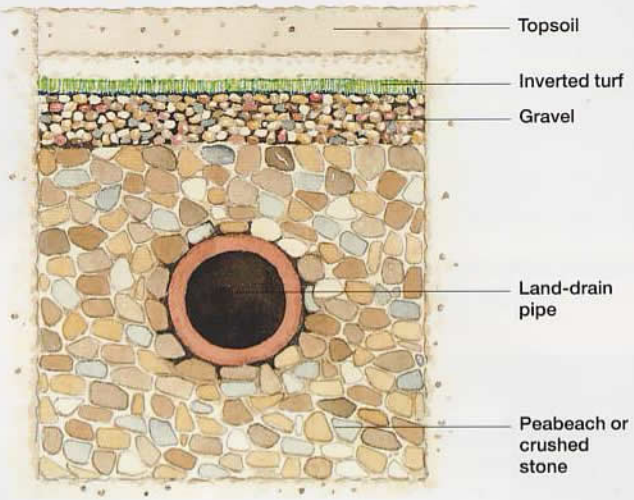
IMPROVING DRAINAGE

Soils that tend to become waterlogged often do so as a result of poor structure and because there is nowhere for the water to go. The vast majority of soils do not actually need (or benefit from) the installation of land drains. Often it is enough to dig over a site because much of the drainage problem may be due to surface compaction. Surface compaction severely reduces the passage of water into the soil and can result in a sticky surface that is prone to "puddling". Installing land drains is usually only done where the water table is very near to the surface or the consequences of flooding are severe (if they threaten housing or use of the area for instance). Land drainage using pipes or "tiles" is a complex undertaking and may be best left to a contractor.

If you have a sloping site you can dig a "soak away" drain at the base of the slope and improve the structure of the soil to encourage the rapid dispersal of water following rain. If you have a fairly flat site, then you should consider making a raised bed for growing crops. Raised beds are easy to manage and avoid the inconvenience of installing (and maintaining) a drainage system.

SECTION THROUGH A LAND DRAIN

This cross-section of a typical land drain shows the various layers of materials from which it is constructed, including the topsoil, an inverted turf or perforated plastic membrane, gravel, peabeach or crushed stone, and the land-drain pipe.



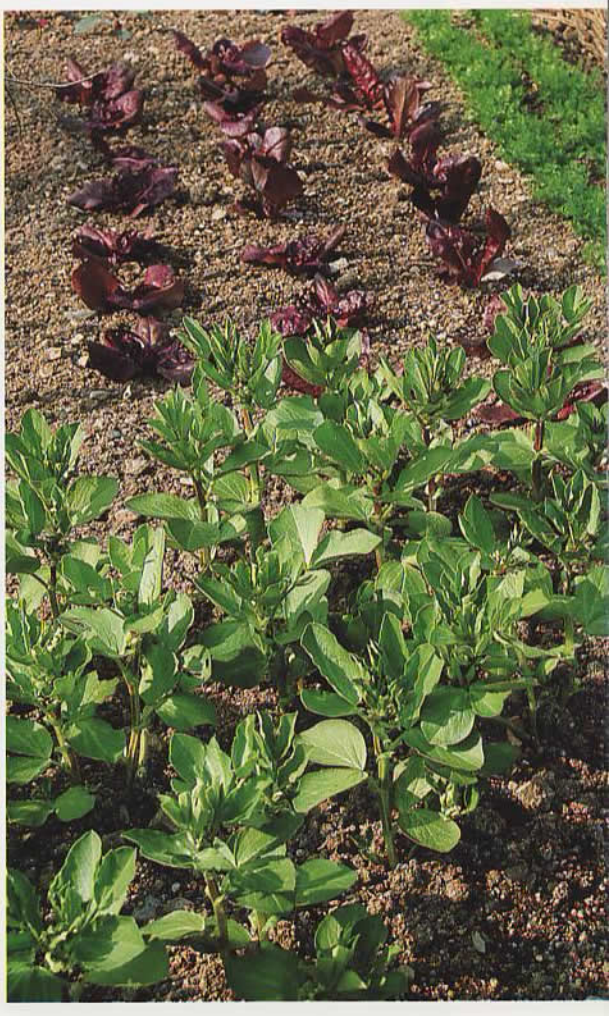
IMPROVING SOIL STRUCTURE



1 *One of the best ways to improve the structure of the soil is to add as much organic material as you can, preferably when the soil is dug. For heavy soils, this is best done in the autumn.*



2 *If the soil has already been dug, then well-rotted organic material can be worked into the surface of the soil with a fork. The worms will complete the task of working it into the soil.*



Above: *A well-prepared soil that is kept free of weeds and dug regularly will result in healthier, more vigorous crops throughout the growing season. A healthier crop will be more resistant to pest and disease attack.*

SOIL CHEMISTRY

While for many of us the word chemistry can be extremely off-putting, the truth of the matter is that everything in life is made up of chemicals. While the pure science of chemistry can be very complex, the chemistry of soil that organic gardeners must master is mercifully simple. A rudimentary knowledge of the chemicals that affect plant growth and how soil chemistry can be controlled and managed is all you need to grow healthy plants in an organic garden.



Above: *You can reduce the acidity of the soil by adding lime some weeks before planting. Test the soil first to see how much is needed.*

OXYGEN

The amount of oxygen in a healthy soil controls the type of life it will support. Nearly all organisms need oxygen to survive. Soils without oxygen are described as anaerobic. Most organisms can survive for short periods under anaerobic conditions, but this causes the accumulation of poisons that can become toxic at high concentrations.

A typical soil has about 50 per cent of its pore space filled by air and 50 per cent by water. Only certain bacteria can remain in anaerobic conditions for long periods of time, although some species of bacteria can readily switch from oxygen-rich to oxygen-poor conditions quickly to adapt to local conditions. Microbes use about 70 per cent of the oxygen in the soil and plant roots use the remaining 30 per cent. Under anaerobic conditions, the efficiency of microbes is poor and decomposition rates are much slower.

WATER

Soil water is vital for all soil life. Without it, microbes cannot grow or remain active and many will go into "hibernation" until water returns. Fungi, on the other hand, are more resistant to water stress than bacteria. With too much water, oxygen levels drop and the lack of air tends to slow down the nutrient cycles driven by microbes. Water is also the medium by which essential nutrients are able to enter the plant.

SOIL pH

The pH scale is an abbreviated form of "Potential of Hydrogen". It is a measure of the degree of acidity or the alkalinity of a solution as measured on a scale (pH scale) of 0 to 14. The midpoint of 7.0 on the pH scale represents neutrality. A "neutral" solution is, therefore, neither acid nor alkaline. Numbers below 7.0 indicate acidity; numbers greater than 7.0 indicate alkalinity.

The level of acidity or alkalinity (pH) of a soil can significantly affect the nutrient availability. Many nutrients become "unavailable" to plants when the soil is either too acid or too alkaline. Microbial activity in soil is also largely controlled by pH. Fungi tend to predominate in acid soils, bacteria in neutral or alkaline soils.

Soil pH is essentially a measure of the acidity of the soil water, although the soil itself is the deciding factor in respect of what this will be.

Most plants prefer or are tolerant of a specific pH range. Some plants, such as the hydrangea, exhibit a different flower colour depending upon the prevailing pH. Most garden plants, especially vegetables, thrive within a range of 6–7 which happens to be where the majority of nutrients are available. It is best to maintain this pH in order to optimize the availability of nutrients. Many garden plants, however, are not too fussy about the pH levels, so if you choose plants carefully, it will not usually be necessary to alter the soil acidity.

ACIDIFYING SOIL

Lowering the pH of a naturally limy soil is difficult because the soil often contains a reserve of calcium that is released immediately upon acidification. Lowering the pH involves the use of flowers of sulphur and is only usually successful over a short period of time.

TAKING A pH TEST



1 *Place the soil in a test tube until it reaches the mark on the side. For the most accurate results, dry the sample first, grind it into a powder and ensure it is free from stones.*



2 *Put a layer of barium sulphate powder into the tube level with the mark. This compound helps the solution to clear rapidly and makes the pH reading clearer.*



3 *Pour in a little of the indicator solution up to the mark shown on the tube. Be careful not to put in too much because this can make the solution dark and difficult to read.*

MAKING A NUTRIENT TEST



1 *Place a small sample of the soil into the test tube up to the mark on the side.*



2 *Add a test solution (in this case one for nitrogen) up to the mark on the test tube.*



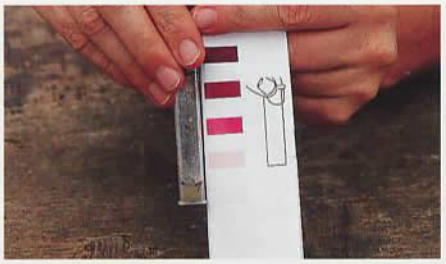
3 *Filter the solution to remove soil particles and leave just a liquid solution.*



4 *Decant the resulting filtered solution into another container for the final stage of the nutrient test.*



5 *Add a small amount of indicator powder. This will react with the solution and enable a colour reading to be taken.*



6 *Shake for about 10 seconds and compare with the chart. Here, the low reading indicates that a nitrogen-rich fertilizer will benefit this soil.*

LIMING SOIL

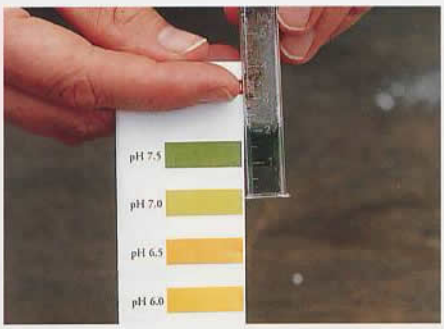
It is generally easier to raise the soil pH than to lower it. Lime neutralizes soil acidity and is commonly applied as ground limestone, chalk or dolomitic limestone (dolodust). Lime requirement cannot be determined from soil pH because it is influenced by soil texture and organic matter content. Clay and humus act as a "buffer" because of their complex chemistry. If soil is known to be acidic, regular light application is preferable to heavier, more infrequent, doses.

HIGHLY ALKALINE SOILS

Soils that are too alkaline suffer trace element deficiencies of manganese, copper, iron, zinc and boron. Phosphates are also less available, their maximum availability being between pH 6–7. Disease organisms can be more of a problem in calcium-rich soils, as many disease-causing fungal agents prefer alkaline conditions. Some plants, such as rhododendrons, are intolerant of high pH and only grow on acid soils, while others, like helianthemums, thrive in highly alkaline soils.



4 *Add distilled water to the mark on the tube and shake the container vigorously for about a minute. Ensure the contents are mixed thoroughly and leave to settle.*



5 *Once sufficiently cleared, compare the colour against those on the chart, choosing the one that most closely matches that of the solution.*

GROWTH RESTRICTIONS IN EXTREMES OF PH

Many vital nutrients that are essential for healthy plant growth become unavailable in extremes of soil pH.

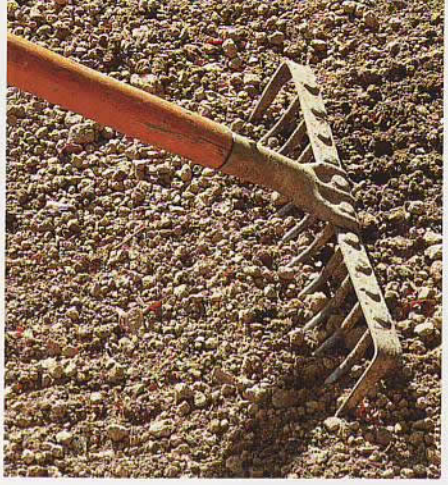
Nitrogen deficiency Most nitrates are released from organic matter and a low soil pH limits the rate of decomposition severely.

Phosphate deficiency Phosphate becomes unavailable outside the 6.5–7.5 pH range. Some plants form relationships with soil-borne fungi that release phosphates in acid conditions.

Trace-element toxicity and deficiency Trace elements, especially aluminium, iron and manganese, are generally more soluble in acidic conditions. Extreme acidity can lead to excessive quantities of trace elements and to plant death. Other trace elements, such as copper, boron and molybdenum, become less available at low soil pH. Molybdenum deficiency affects legumes, which will not grow in acid soils.

DIGGING AND CULTIVATION

Every organic gardener's goal should be a healthy soil to support plant growth and development. Digging is one of the commonest ways to create a rich, fertile and ultimately productive soil. It can be hard work at the outset, particularly on sites not cultivated for some time, but the results – in the form of healthier, more productive plants – are worth it. Quite simply, what you get out of your soil will depend upon what you put into it.



Above: *After a winter exposed to the weather, most soils can be easily broken into a fine tilth with a rake.*

THE BENEFITS OF DIGGING

Winter is the commonest time to dig, but soil can be dug at any time of the year if the conditions are right. Avoid working the soil when it is too dry and impenetrable, or too wet and sticking to your tools and boots. Clay soils may be best dug in mid- to late autumn to allow the action of frost to make the soil more suitable for final cultivation. Lighter soils are best dug in the spring or immediately prior to planting the site. Done properly, digging increases the amount of air space in the soil, which in turn benefits soil-dwelling organisms and plant roots due to the increase in oxygen available. It also lets you add organic matter that will feed these vital denizens of the soil and aid nutrient cycling. Calculate how much organic matter you will need before you start. You should aim to add about 30 per cent of the volume cultivated. A 20m^2 (220ft^2) plot cultivated to one spade's depth will need 2.5 cubic metres (88 cubic feet) of manure or garden compost.

SINGLE DIGGING

This method involves digging down to the depth of one spade (this is called a spit). Single digging suffices on light free-draining soil as long as there is no layer of compacted stones in the topsoil. Much of the procedure is the same as for double digging, but the subsoil is left undisturbed. Mark out the position of the bed. Remove any turf or vegetation from the surface, put to one side and then bury it in the bottom of the bed as you proceed. Work across the bed, digging out a trench that is two spits wide and a single spit deep, and place the soil to one side. Remove stones and perennial weeds as you go. Fork well-rotted manure or compost into the trench. Begin digging a new trench behind the first. Throw the soil forward into the first trench, burying the organic matter. Repeat this process of trenching down the bed until the last trench has been dug. Add organic matter to the base and fill the trench with the soil dug from the first trench.

DOUBLE DIGGING

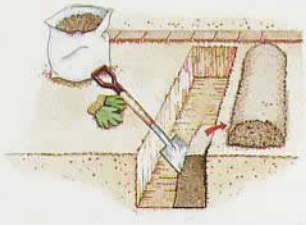
This is a method for deeply digging the soil, in which the soil is broken up to a depth of approximately 70cm (28in) or more. The method usually involves digging a quantity of soil and setting it aside while aerating and sometimes adding an amendment to the subsoil below, then returning the topsoil. There are several methods of double digging, all of which have their advocates. Two methods for double digging are described here.

First, define the area where the digging will take place, making an estimate of the area to be dug. Dig a trench, 30cm (12in) wide and a spit deep, across half the width of the bed. Place the excavated soil next to the other half, placing it on to a tarpaulin or similar covering if the surface needs protection.

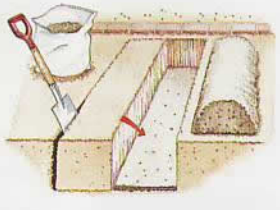
When the trench is complete, fork the subsoil, rocking it back and forth, to loosen it down to a depth of about 30cm (12in). Then, spread a layer of garden compost over

SINGLE DIGGING

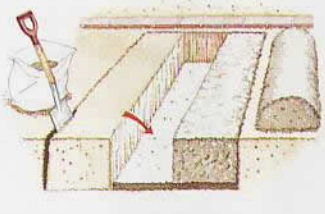
Single digging is the simplest method of cultivation. It is well suited to light soils or those soils that have been well worked for a number of years. It simply involves digging and inverting the soil to a single spade's depth, leaving the subsoil below undisturbed.



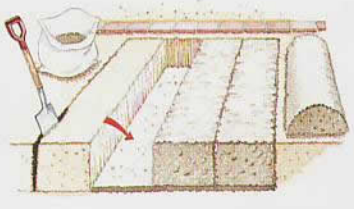
1 *Start by digging a single trench across the width of the plot. Put the soil from the first trench to one side because you will need to use it later in the final trench.*



2 *Put a layer of manure in the bottom of the trench. Dig out the next trench and cover over the manure in the first trench with the earth taken from the second trench.*



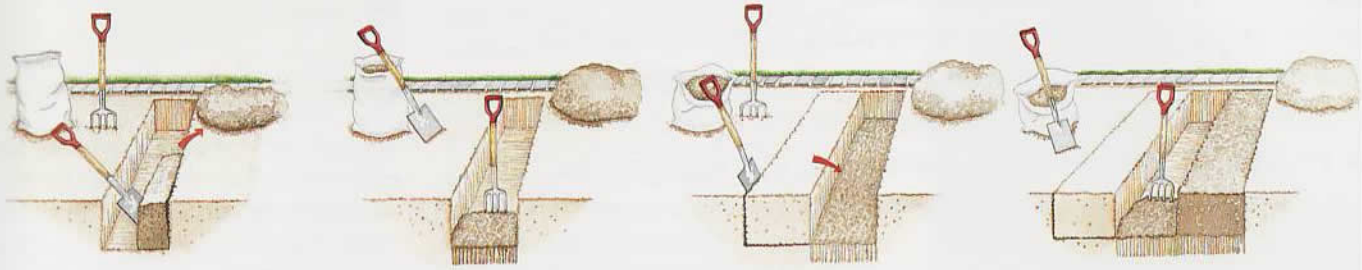
3 *Repeat this process of adding manure to each trench and filling in with earth from the next, breaking up the soil as you go and keeping the surface as even as possible.*



4 *Continue down the length of the plot until you reach the final trench. This should be filled in with the earth taken from the first trench, which was set to one side.*

DOUBLE DIGGING, METHOD ONE

Double digging is a good method for compacted, heavy or poor soils that are in need of rejuvenation. It involves a deep cultivation of both the topsoil and subsoil and is well worth the hard work, producing a wonderful soil in which plants will thrive.



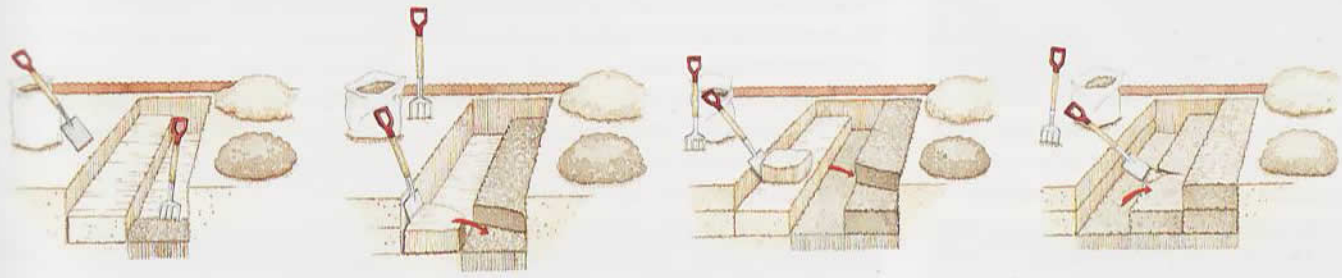
1 *Dig a wide trench, placing the soil to one side to be used later when filling in the final trench.*

2 *Break up the soil at the bottom of the trench with a fork, adding manure to the soil as you proceed.*

3 *Dig the next trench in the bed, turning the soil over on top of the broken soil in the first trench.*

4 *Continue down the plot, ensuring that subsoil from the lower trench is not mixed with topsoil of the upper.*

DOUBLE DIGGING, METHOD TWO



1 *Keeping soil from each level separate, dig the first trench two spits deep and fork over. Dig the second trench one spit deep.*

2 *Add organic material to the first double trench and dig the lower spit of the second trench into it.*

3 *Dig an upper third trench one spit deep, and place the soil on top of that already placed in the first trench.*

4 *Continue, ensuring that the topsoil and subsoil do not mix. Fill in remaining trenches with soil taken from the first one.*

the exposed subsoil. Move over one spit's width in the bed, and begin to dig out another trench, moving and inverting the excavated soil into the adjacent trench that was just dug. When you get to the end of the bed replace the soil which was set aside.

When the digging is finished, level the site prior to planting. More garden compost (approximately 8cm/3in) can be spread over the surface and forked in at this stage.

You do not have to dig the entire garden all at once. Instead, work on small areas, say, one metre (yard) square, whenever you wish. Once you double-dig a bed, it is important not to walk on it. After all, the whole point of double digging is to loosen the topsoil and the subsoil to a sufficient depth so that the roots of the plants can grow unrestricted and water can readily percolate through the soil. Walking on the soil will simply pack it down again.

There is a second method of double digging that is less commonly used, which enriches the soil to a greater depth.

SECONDARY CULTIVATION

This normally involves the nourishing of the soil after it has been cultivated by digging and usually entails the addition of some form of organic matter during, or immediately after, its completion. Secondary cultivation also describes light digging used to control weeds or incorporate green manures. The tool generally used for this is a fork. Light forking is often the best method to use in areas with permanent plantings of perennial plants or shrubs.

USING A ROTAVATOR

A rotavator is a useful labour-saving device for breaking down dug clods and creating a fine, free-running "tilth" that can easily be levelled for planting or seed-bed preparation.

TIPS FOR DIGGING

Digging can be hard work, but simply following the tips given below will help you to avoid strains and injuries.

- Start with a small area, pace yourself and avoid straining your back.
- Use a spade that is right for you and the job. It should be a little higher than hip height when held vertically.
- Do not try to lift more than you can handle. You will dig for longer periods of time by taking smaller amounts.
- As you work, try to establish a rhythm that you can maintain at all times.
- When doing a lot of heavy digging, scrape the blade clean now and then, and, if necessary, use a file to sharpen the end of the spade, following the original bevel of the blade.

NO-DIG GARDENING

As the name suggests, no-dig gardening is a method of growing plants without cultivating the ground they occupy. While this may seem unnatural to some confirmed tillers of the soil, it is actually the most natural method available. No-dig gardening mimics the natural cycle. After all, plants have grown on the earth's surface for over 400 million years without people digging the soil for them. This approach also has the advantage of being less labour-intensive.



Above: *In nature, organic matter accumulates on the soil surface, breaks down and is worked into the soil by worms.*

ESTABLISHING A NATURAL CYCLE

Essentially no-dig gardening relies upon natural soil processes combined with the action of soil organisms to produce a good soil structure and natural nutrient cycles. There are numerous ways that this can be done, but all rely upon inputs from the top down. A thick top-dressing of organic matter is placed on the surface to be absorbed by the soil itself. Less laborious than digging, the no-dig method does need planning and careful input in order to be successful, although a properly prepared no-dig bed will be every bit as effective as a conventionally cultivated one.



Left: *Many organic gardeners grow crops such as potatoes quite successfully without ever resorting to digging.*

WHAT ARE THE BENEFITS?

Assuming weeds can be controlled, most vegetable crops can be grown with reduced tillage. The key features of a no-dig vegetable-growing system are to keep the soil covered with organic mulch as much of the time as possible and to keep off the soil. The beds are left permanently in place, and there is no cultivation.

Plants grown without tillage use water more efficiently, the water-holding capacity of the soil increases, and water loss from run-off and evaporation are reduced. For crops grown without irrigation in drought-prone soils, this more efficient use of water can translate into higher yields.

In addition, the organic matter in soil and populations of beneficial insects are maintained, as are earthworm populations and microbial activity. Soil and nutrients are less likely to be lost from the ground, less time is required to prepare the soil for planting, and, since there is less bare soil, there will be fewer opportunities for weeds to get established. The mulch of organic matter also helps to keep weeds down.

WHAT ARE THE DISADVANTAGES?

Potential problems associated with the no-dig method are compaction, flooding and poor drainage. However, if the water-holding capacity of a soil improves, no-till systems may produce higher yields. Soil temperatures under organic mulch can be several degrees lower than bare soil or soil under a plastic mulch. Although the lower temperature can be an advantage, especially in the summer when soil temperatures under plastic can be excessive, it can delay crop development.

WHAT ARE THE BENEFITS OF NO-DIG SYSTEMS TO THE ORGANIC GARDENER?

Although no-dig beds may require a little longer to establish initially than cultivated plots, they do offer considerable labour-saving advantages to the organic gardener. They also suffer very few disadvantages when these are weighed against the considerable advantages.

Advantages

- Plants use water more efficiently.
- Better water-holding capacity of the soil.
- Reduced water loss from run-off and evaporation.
- Higher crop yields in areas prone to drought.
- Organic matter in the soil and soil organisms are maintained at higher levels.
- The lower temperature can be an advantage, especially in summer when soil temperatures under plastic can be excessive.
- Soil and nutrients are more easily maintained.
- Less time is required to prepare the soil for planting.
- Fewer weeds become established due to the mulch of organic matter and the lack of bare soil.

Disadvantages

- Soil can become compacted or poorly drained if it is not properly managed.
- Soil temperatures under an organic mulch can be several degrees lower than bare soil, which can delay the development of crops.

MAKING A NO-DIG BED

A bed system which includes permanent paths is essential if digging is to be eliminated from gardening tasks. Planning the area so that all parts of the bed can be reached from the paths means that you can grow your crops closer together (you do not need to leave extra space for access) and you will be able to harvest more from a smaller area.

Mark out the beds on the ground or build simple raised beds with wooden sides. Alternatively, those wishing to make a more permanent edge could consider a low brick wall. By raising the bed it is possible to create a deep bed of good-quality soil that will warm up more quickly than the surrounding soil. A raised bed also means you do not have to bend down so far to carry out routine tasks and the method is tailor-made for disabled gardeners. Raised edging is also useful for attaching supporting hoops, crop covers and cloches. Edges such as these are also ideal for providing barriers for pests. Devices such as water traps or copper paper are easily attached to them to prevent slugs and snails from entering the bed.

Beds should be no more than 1.2m (4ft) wide and paths at least 30cm (12in) wide with every other path double this width to allow for easy wheelbarrow access. Individual beds should be no longer than 3.5m (12ft) otherwise you will waste a lot of time walking around them. The beds can be of any design, from a simple series of parallel rectangles to a more complex design of interlocking shapes. Whatever design you choose, try to follow the same recommended bed and path widths, remembering that narrow angles and very small beds are more difficult to construct and use space less efficiently.



Right: *Green manures are usually dug into the soil, but they can still be used in a no-dig system. The manure can be cut down and left as a mulch.*

PLANTING POTATOES IN A NO-DIG BED



1 *Place a thick layer of well-rotted manure or garden compost on the bed to be planted. This should be quite deep – at least 15–20cm (6–8in) – as it will quickly decompose during the growing season. Early planting is possible by manuring in winter and covering with plastic sheeting to warm the soil. The potatoes are planted directly into this and may be more closely spaced than those planted in soil, perhaps as close as 30cm (12in) apart.*



2 *Apply a generous mulch of straw once the bed is planted to give cover to the tubers and to suppress weed growth on the manure or compost. Spread a second layer of composted organic material over the straw. Add another layer of straw and composted material. Water the bed well. Once the potato plants begin to emerge, more straw can be laid down on to the bed, as the material put down earlier in the season will begin to compost down.*



3 *As the potato stems grow, mulch heavily in order to ensure that no light reaches the developing tubers. The potato crop will mature at the same rate as potatoes grown in ordinary soil. The no-dig system is possibly the best method for heavy clay soils that are prone to waterlogging. Potatoes grown in this way are also easy to harvest as there is no digging and the potatoes are cleaner once they are ready for harvesting.*

SOIL CONDITIONERS

There is quite a range of conditioners available to the organic gardener for improving the soil. Some are free (if you do not count the time taken in working and carting them), others are relatively cheap, while those bought by the bag can be quite expensive. The best option for the organic gardener begins with using the materials that are closest to hand. Smaller gardens or those that are newly established may require soil conditioners to be brought in. This section looks at some of the options.



Above: *A well-conditioned soil will pay dividends in terms of enhanced plant growth and development.*

FARMYARD MANURE

This is usually freely available, although these days it comes increasingly from stables rather than farms. It contains a small amount of nutrients although it usually makes the soil more acidic as it decomposes and should always be well rotted before use. It can also contain lots of weed seeds, which often come from the bedding used for the animals. Occasionally there can be problems if the straw used has been sprayed with pesticides, so always be sure of your source. Farmyard manure is usually cheap or occasionally free for the taking.

BURYING GREEN WASTE

If you have space, you can simply open a trench in the soil and bury your green waste 20–30cm (8–12in) deep under the soil. It will take perhaps two to three months during the warm season to break down. Avoid planting crops in the soil above until the material has decomposed properly.



Left: *Animal manures can provide both nutrients and valuable organic matter when added to your garden soil.*



Left: *Spent mushroom compost is an ideal material for improving the structure of many types of soil.*

LEAF MOULD

Many gardeners believe leaf mould to be the finest addition to any soil. The product itself forms naturally under the closed canopy of forest trees. It is, as the name suggests, the rotted product of fallen leaves. It is not particularly rich in nutrients but it has an extremely good ability to condition a soil and encourages natural nutrient cycles in your soil. It is usually made by the gardeners that wish to use it and is rarely sold on. Anyone who has a ready supply of leaves will find this an easy material to make.

Start by gathering up leaves in the autumn and stack in a chicken-wire cage to prevent them being blown back over the garden. Do not add any greens or other materials to the pile. The heap will rot down slowly and be ready for use in one to two years. It can be sited in a dark corner where nothing else will grow, but you must ensure that you keep the pile moist all year round. The wire cage can be removed after two months or so and used again the following autumn. Alternatively, two permanent pits, sited side by side, can be filled (or emptied) in alternate years. Smaller quantities of leaves can be pushed into black plastic sacks with the top closed and with holes pierced by a garden fork around the sides and bottom of the bag to allow some airflow.

SPENT MUSHROOM COMPOST

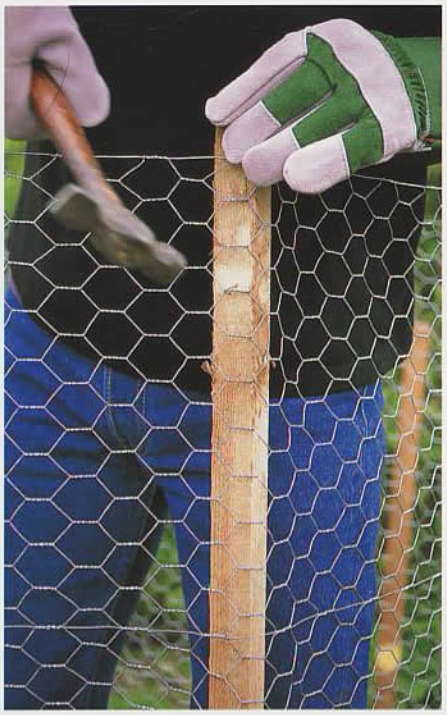
This is one of the few types of organic matter to have a slightly alkaline effect on the soil. It is a uniform and friable mixture of stable organic materials that is a waste product of the mushroom-growing industry. It is usually quite inexpensive. The composting and growing processes that produce this material bind nutrients to the organic matter, resulting in a substance that holds on to nutrients more readily than fresh or non-composted organic wastes. In addition, the compost has good moisture-holding abilities.

Spent mushroom compost is slightly alkaline with a pH ranging from 7–8 but generally around 7.3. There are few weed seeds, insects or pathogens because the compost is pasteurized before it is removed from the mushroom house. The addition of spent compost to garden soil can result in a

BUILDING A LEAF MOULD PIT



1 *Drive in four 1.5m (5ft) posts to form the four corners of a square on the ground. The posts should be spaced about 1m (3ft) apart and there should be just over 1m left above ground once the posts are driven in.*



2 *Attach chicken wire – a 1m (3ft) wide roll is needed for this – to the stakes using "U"-shaped fencing staples, hammered in firmly. Pull the wire tight across the length of the roll before attaching it to the next post.*



3 *Once the wire has been securely stapled to the posts all the way around, cut it with wire cutters, folding the sharp ends under the attached mesh so that they cannot cut you.*



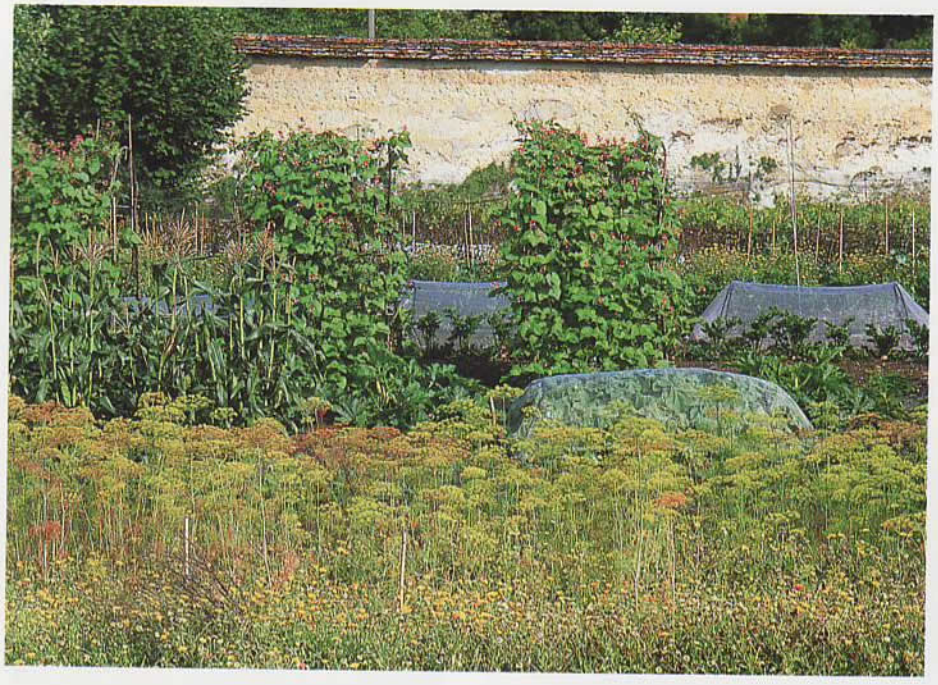
4 *Place fallen leaves into the "pit" until it is full. Firm the leaves lightly in layers as you go, so that the pit is completely packed with leaves but still contains a little air.*



5 *After a year or two, the leaf mould is ready and should be applied to the soil in late winter or early spring in order to gain the most benefit.*



6 *It is a good idea to build two or more pits and rotate their use as a single pit will not be emptied in time to receive the new lot of leaves in the following autumn.*



Left: *Beans and other leguminous plants are an important part of a successful organic vegetable garden, "fixing" their own nitrogen and so helping to raise levels of soil fertility.*

higher pH, increased nutrient-holding capacity and better soil structure. The main disadvantage occurs when the compost is first mixed with soil, as bacteria convert the proteins in the compost to ammonia, which can be toxic to young plants. Always ensure the source of your compost is an organic mushroom grower where possible.

VEGETABLE INDUSTRIAL WASTE

Some by-products of the food industry, such as spent hop waste and cocoa shells, can be beneficial as soil conditioners in the organic garden. They are useful in terms of their ability to improve soil structure. However, their smell, which may be described as rancid ale or beer with hops, or sickly cocoa, is often enough to put people off. They are sometimes marketed commercially although they may be available as a local by-product of industry. Whatever product you use, it should be well rotted before it is used as a soil conditioner.

WORM COMPOST

Worms can be used to compost your kitchen waste both indoors and outdoors, although both methods have their limitations and advantages.

The materials that are being composted are consumed by the worms and then excreted as worm casts. This process binds the nutrients consumed into a form that can be used by plants and reduces the volume of the original materials. These worm casts are covered with slow-dissolving, semi-permeable mucus that acts as a time-release mechanism for the nutritional content of the worm casts and also gives the finished compost good water-retentive qualities.



Above: *Brandling or tiger worms readily reduce vegetable matter into a useful compost material within a wormery.*

A WORMERY

Worms are an effective way to break down kitchen waste such as vegetable scraps. They will eventually eat their bedding as well as the kitchen waste. The resulting worm casts are a nutrient-rich soil conditioner.



Worm colonies can be built in a similar way to a cold pile compost heap, with materials added as they become available. Excessive heat and frequent pile turning are not needed. Too much heat will actually kill the worms. Alternatively, a purpose-built wormery can be used. Both methods require materials to be placed in a shaded, cool and moist location. The worm colony must not become heated by the microbial action that takes place in normal composting. If the colony does get hot, it may cause the loss of the worms if they do not have cooler areas to which they can escape.

For an indoor worm colony, the wormery (a sealed, ventilated box with a close-fitting lid) is filled with bedding materials (usually damp shredded newspaper or similar) and the worms are added. Vegetable waste from the kitchen is placed on top or a few inches under the bedding where the worms can find and devour it. Eventually, the worms eat their bedding as well as the vegetable scraps. The finished worm castings can be removed and used. New bedding and kitchen scraps are then placed in the container and the worms returned to make a new batch of compost. Many purchased wormeries have the facility to collect the liquid by-product of the worms' activities, which makes an excellent liquid plant food.

It is advisable to check the pH level of the wormery every now and then. Thin, white, thread-like cotton worms are usually an indication that the pH is too low. Adding some calcified seaweed can help to counter this acidity, as can a regular addition of eggshells.



Above: *Place a thick layer – about 8–10cm (4–5in) – of well-rotted organic matter into the base of a trench dug to a spit's depth (the depth of a spade blade). Use a fork to break up the material and to ensure that there is plenty of air space in the soil to aid the breakdown of the material and help soil organisms to cycle the nutrients.*



Above: *Leafy crops benefit from the addition of organic matter because it encourages nitrogen-fixing bacteria to do their all-important work in the soil.*

THE BENEFITS OF ADDING ORGANIC MATTER

Using organic matter as a mulch or soil conditioner will help to warm up the soil earlier in the spring. This in turn will allow for the earlier planting of some types of plant.

- Organic matter inoculates the soil with vast numbers of beneficial microbes and provides the food source that soil-dwelling microbes need to live. These microbes are able to extract nutrients from the mineral part of the soil and eventually pass the nutrients on to plants.
- Adding organic matter to your soil improves the way in which water interacts with the soil and improves the overall soil structure. All soils can benefit from the regular addition of organic matter.

To sandy soils

- Organic matter acts as a sponge to help retain water that would otherwise drain down below the reach of plant roots. This has the benefit of protecting plants against drought.

To clay soils

- Organic matter helps to increase the air space within the soil, making it drain more quickly. This ensures that the soil does not become waterlogged or dry out into a brick-like substance.

MAKING GARDEN COMPOST

Every organic garden should have at least one compost heap, where garden and kitchen waste can be broken down by microbes and other soil-dwelling creatures to produce a good medium-fertility soil improver. Making compost is not difficult and is an excellent way to recycle waste. Many gardeners take great pride in their home-produced compost and all gardens can benefit from this sustainable approach to soil improvement.



Above: *Even a stack of old tyres can be recycled and used to make an effective compost heap.*

THE SITE

A position in full sun will give the compost heap additional heat, allowing the contents to decompose more rapidly. If time is not a key factor, partial shade or even full shade will do. Compost is easily made in a freestanding pile in a sunny or partially shaded area in the garden. Alternatively, a simple structure can be used to contain the pile. A variety of materials can be used to make these structures, including wood, bricks, pallets, a wire cage or even a stack of used tyres. Whichever method you use, you must provide good drainage. An average heap should be around a cubic metre (10 cu. ft). It can be much larger, but any smaller and it will not be as effective.

When adding waste materials to the heap, the items should be as small as you can make them. The more surface area that is exposed, the quicker it will decompose. A chipper or shredder is a big help. Many gardeners are keen advocates of adding a small amount of good topsoil in order to introduce microorganisms that will kick-start the process of decomposition. Compost heaps in containers can be built up with successive layers of "green" and "brown" materials, separating these with thin layers of topsoil.

Sifting the pile is the final stage of the process, with any large pieces of residue being returned back to the new heap.



Left: *Composting your garden and kitchen waste ensures that you return essential nutrients to the soil.*

COMPOST INGREDIENTS

The potential ingredients for your compost heap will be either "brown" or "green". Browns are dry and dead plant materials, such as straw, hay, dry brown weeds, autumn leaves, nutshells, shredded paper, pine needles, tough plant stems and wood chips or sawdust. Because they tend to be dry, browns often need to be moistened before they are put into a compost system.

Greens are fresh (and often green) plant materials, such as green weeds from the garden, fruit and vegetable scraps, green leaves, grass clippings, tea bags, coffee grounds, seaweed, eggshells, fish scraps, green manures and fresh horse manure. Compared with browns, greens contain

MAKING A HOT PILE COMPOST HEAP



1 *Starting with an empty compost bin, place a layer of "browns" – straw, old leaves and chipped wood are ideal – in the base of the bin. If the bin is positioned over bare soil, include some fine twiggy material to help to circulate air to the base of the pile.*



2 *Add a layer of brown compost materials, such as autumn leaves, plant stems and wood chips, which should be approximately 15cm (6in) deep, and ensure that it is of an even thickness. The material should be lightly firmed in.*



3 *Add a new layer of "greens" to the compost bin. Most plant material can be used for this, although you should avoid too much fibrous or woody material such as plant stems. Never include weed seeds if possible.*



Above: It is often advisable to have two or more compost heaps at any one time in order to ensure a steady supply.

more nitrogen. Nitrogen is a critical element in amino acids and proteins, and can be thought of as a protein source for the billions of multiplying microbes.

A good mix of browns and greens is the best nutritional balance for microbes. This mix also improves the aeration and level of water in the pile.

THE "COLD PILE" METHOD

Make a pile of "browns", such as autumn leaves, moisten them well and then slowly incorporate "greens" such as kitchen waste or lawn clippings over the next year (this method can take a full year to finish the compost). If it gets very cold in winter, cover the heap with cardboard or old carpet and peel this back to stir in any greens. In this type of composting, there are never enough high-nitrogen greens to get the pile really hot. Turn the pile a minimum of once a month if you have not recently added any greens, thereby breaking up the decaying mass and making it friable. If you do use this method, be sure you always have at least as much browns as added greens, as too many greens will just create a slimy, smelly mess. Some compost heaps (those with lots of greens added) may reach very high temperatures, some even reaching 70°C (158°F), thereby killing weed seeds. Cold piles, on the other hand, do not and it is best not to add any weed wastes that will contain seeds. If you do, you could risk spreading weed seeds across your garden in their own growing mix when you come to use the compost.

THE "HOT PILE" METHOD

Wet the ground under the pile and add twigs or other un-shredded browns to provide some aeration at the base. Layer the rest of your materials, alternating green and brown layers of about 15cm (6in) thickness, and add water as you go. Topsoil can also be added as a 2cm (¾in) layer between each cycle of green and brown materials. Finish the pile with a layer of browns. Cover the pile with a lid or piece of carpet to keep out rain and conserve heat. Check to see that your pile becomes hot within a few days. Turn the pile to decrease composting time. This action allows all the material to be exposed to the hot centre, thereby increasing aeration. Do this once a week in the warmer season, and once a month in cooler periods. The pile's heat should peak every time you turn it, although the peak temperature will be lower with each turn. Always make sure that the pile remains moist, but avoid over-wetting.

COMPOSTING MATERIALS

Many items can be composted into valuable soil conditioners. Whether because of toxins, plant or human diseases or weed problems, some things should never be used.

Good compost materials

Animal manure
Fallen leaves
Grass/lawn clippings
Hay and straw from organic farms
Kitchen waste
Prunings from the garden
Sawdust
Shredded browns
Soot and charcoal
Spent hops or cocoa shells
Spent mushroom compost
Weeds and other garden wastes

What not to compost

Chemically treated wood products
Diseased plants
Human and pet waste
Meat, bones and fatty food wastes
Pernicious weeds



4 *Continue adding greens until you have a layer about 15cm (6in) thick, the same depth as the browns below. Lawn clippings should be placed in layers of about 10cm (4in) or mixed with other green waste to avoid the layer becoming slimy and airless.*



5 *Kitchen refuse, such as vegetable waste, can also be added and is usually classed as a "green". You can include a thin layer of soil to add microorganisms before the next layer of "browns". Continue layering until the bin is full, then water and cover.*



6 *After two to three months, you should have well-rotted garden compost, which, due to the heat of the pile, will be largely free from weed seeds, pests and diseases. Once the bin has been emptied, it can be refilled in the same way.*

GREEN MANURES

Sometimes referred to as "cover crops", green manures are plants that are grown to benefit the soil rather than for consumption or display. Green manures replace and hold nutrients, improve the structure of the soil and increase its organic material content. They also smother the soil and so prevent weed growth. Green manures also "fix" atmospheric nitrogen. They are easy to grow and can be used to improve the soil when manures are not readily available.



Above: *Growing a green manure is an easy and effective way in which to add some organic matter to the soil.*

BENEFITS OF GREEN MANURES

At any time of year, but especially in winter, the soil loses nutrients if it is bare for six weeks or more. Green manures help to counteract this and maintain a more even soil temperature and moisture content. Many green manures grow deep roots to tap resources unavailable to some crops. Others produce a fibrous root system to help build structure in the soil, while many have flowers that attract pollinating insects.

TYPES OF GREEN MANURE

Some green manures are nitrogen-fixers, using bacteria that colonize the nodules on their roots. These microbes take nitrogen out of the air and convert it into a form that plants can use. Green manures are usually divided into two groups: legumes and non-legumes. Leguminous manures include clover, peas, fava beans and alfalfa. Despite their nitrogen-fixing abilities, legumes have slow autumn growth and add less organic content. They can also be less winter hardy.

Winter rye is the most commonly grown non-leguminous cover crop, but oats, wheat, oilseed rape and buckwheat are also used. Although they do not add nitrogen to the soil, they help maintain levels and have the additional advantage over legumes of growing faster through the autumn, thereby giving better weed suppression. They also tend to break down more slowly than legumes and add more organic matter to the soil. You may wish to use a combination of green manures in order to balance the benefits of the different types.

DEEP-ROOTED GREEN MANURES

The roots of certain green manure "crops" work through the soil, holding it together as they grow. Once dug in, however, they help to make it crumbly and friable as they rot. Some green manures have very deep roots that reach down into the subsoil and can harvest nutrients that are unavailable to other garden plants. In this respect they are a form of biological double digging.

PLANTING GREEN MANURES

Winter green manures should be planted early enough to give about four weeks of growth before cold weather stops their growth. Spring or summer crops must be given sufficient time to develop before they are dug in. After preparing the soil, plant large-seeded cover crops in shallow, closely spaced furrows. Smaller seeds can be broadcast over the surface and covered with a light raking, watering if needed until they germinate. Dig the crop in once it is ready, allowing at least three weeks before you intend to plant to give time for the material to rot down. It is best not to allow green manures to go to seed as they all have the potential to become weeds.

Gardens are traditionally dug over and manured in autumn, then left bare over winter. Many nutrients can be lost during this time due to the leaching action of rain. A hardy green manure sown in the autumn can be dug in the following spring, yielding nutrients to a newly sown or planted crop.

USING GREEN MANURES



1 *Sow the seed evenly across the area where you plan to grow the green manure. Either broadcast the seed or sow larger seed thinly in shallow drills and close rows.*



2 *Lightly rake in the seed so that it is covered and will germinate quickly. Water the area thoroughly if there is no rain due or if it does not rain for the following 48 hours.*



3 *Once the seed germinates, allow it to grow a little before digging it into the soil. Never let green manure crops set seed or they will become a weed in later crops on the site.*

TYPES OF GREEN MANURE

Green manure for growing over winter

These species can withstand moderate to hard frost for a long period and can be cut down in the spring, prior to cultivation. The shorter types can also be used as catch (cover) crops around winter vegetables or biennial crops for harvest in the early spring. This protects bare soil, prevents nutrient leaching and creates a more stable soil environment.

GREEN MANURE	SOWING TIME AND METHOD	HEIGHT	WINTER HARDY?	NITROGEN-FIXING ABILITY	TERMS OF GROWTH	DIGGING IN	OTHER NOTES
Alfalfa *Medicago sativa*	Early spring to mid-summer; broadcast at 3g (1/10oz) per square metre (yard).	100–150cm (3–5ft)	Yes	Yes but poor	Perennial. Grow for several months or more than one season.	Any time. Medium effort if young. Hard if left for more than one season.	Very deep rooting. Will grow on most soils. Dislikes acid or waterlogged soils, but drought resistant.
Asilke clover *Trifolium hybridum*	Mid-spring to late summer; broadcast at 3g (1/10oz) per square metre (yard).	30cm (12in)	Yes	Yes	Several months	Any time. Medium effort.	Will withstand wetter soils than other clovers but more prone to drought. Shallow rooted.
Essex or red merviot clover *Trifolium pratense*	Mid-spring to late summer; broadcast at 3g (1/10oz) per square metre (yard).	40cm (16in)	Yes	Yes	Several months	Any time. Easy, little effort.	Prefers good loamy soil. Can be mown or cut several times per season and used for compost.
Grazing rye *Secale cereale*	Late summer to late autumn; broadcast at 30g (1oz) per square metre (yard) or thinly in rows 20cm (8in) apart.	30–60cm (12–24in)	Yes	No	Autumn to spring	Before flowering. Hard work.	Grows in most soils. Keep watered during germination, else yield is poor. Sow thickly to smother weeds.
Phacelia *Phacelia tanacetifolium*	Early spring to early autumn; broadcast at 3g (1/10oz) per square metre (yard) or thinly in rows 20cm (8in) apart.	60–90cm (12–36in)	Yes	No	2 months in summer; 5–6 months over winter	Before flowering. Easy, little effort.	Grows in most soils. Quick to grow in summer. If left, will produce mauve flowers that bees love.
Trefoil *Medicago lupulina*	Early spring to late summer; broadcast at 3g (1/10oz) per square metre (yard).	30–60cm (12–24in)	Yes	Yes	Several months to a year	Any time. Medium effort.	Will grow in most soils but dislikes acid. Can be used for undersowing. Dense foliage.

Green manure for warm-season growing

Plants for use in the spring and summer have to be quick growing in order to cover the ground and yield benefit within a short period of time. They are generally slightly tender, although lower-growing species can actually be used as a catch crop around other seasonal crops.

GREEN MANURE	SOWING TIME AND METHOD	HEIGHT	WINTER HARDY?	NITROGEN-FIXING ABILITY	TERMS OF GROWTH	DIGGING IN	OTHER NOTES
Bitter lupin *Lupinus angustifolius*	Early spring to early summer 4cm (1½in) deep; 3cm (1¼in) apart; in rows 15cm (6in) apart.	50cm (20in)	Mild winters	Yes	2–3 months	Before flowering. Easy, little effort.	Prefers light slightly acidic soil. Foliage not very dense. Deep rooted.
Buckwheat *Fagopyrum esculentum*	Early spring to late summer; broadcast at 10g (1/3oz) per square metre (yard) or thinly in shallow rows 20cm (8in) apart.	80cm (32in)	No	No	2–3 months	Before or during flowering. Easy, no effort.	Grows on poor soils. If allowed to flower, attracts hoverflies to aid pollination of crops.
Crimson clover *Trifolium incarnatum*	Early spring to late summer; broadcast at 3g (1/10oz) per square metre (yard).	30–60cm (12–24in)	Mild winters only	Yes	2–3 months or over winter	Before flowering. Medium effort.	Prefers sandy loam soil but will tolerate heavy clay. Large red flowers attract bees.
Fenugreek *Trigonella foenum-graecum*	Early spring to late summer; broadcast at 5g (1/5oz) per square metre (yard) or thinly in 15cm (6in) shallow rows.	30–60cm (12–24in)	Mild winters	No	2–3 months	Any time before flowering. Easy, little effort.	Prefers good drainage but will tolerate heavy or light soil.

BASIC TECHNIQUES

Most gardening techniques, from weeding and feeding to pruning and propagation, are straightforward and and easy to achieve if you plan and organize the task in hand. The procedures described here will help you to master the basics of organic gardening. You may well develop your own methods in time, based upon the techniques shown here as well as those you that learn from other gardeners. Always make sure that you are clear what you want to do and always approach a task positively. Gardening should bring enjoyment as well as a sense of satisfaction that comes from creating a thriving organic paradise in your own backyard.

Left: *A flourishing garden plot is the end result of careful planning and preparation as well as regular maintenance.*



Above: *A well-prepared, weed-free plot is the ideal starting point for successful plant growth and development.*



Above: *Both weeds and crop residues can be recycled in the organic garden by composting and then returned to the soil.*



Above: *Taller plants may need some form of support. In this case, willow branches have been used to support* Lysimachia.

WEEDING AND WEED CONTROL

Many people are put off organic gardening because they do not like the idea of weeding. Not having the "quick fix" of weed-killing chemicals can make this task seem daunting. It is, however, worth considering that a well-maintained garden has less weeding to do than you might think. In addition, it can be a relaxing, even therapeutic, task and there is very little that is more satisfying in the garden than a freshly weeded plot.



Above: *Hoeing is an effective way of keeping a garden plot free of weeds. Pull a draw or swan-neck hoe towards you in a series of chopping movements.*

WHAT PROBLEMS DO WEEDS PRESENT?

Weeds compete with garden plants of all types for essential nutrients, light and water. Uncontrolled weed growth may kill plants that are less vigorous or seriously inhibit their development. Weeds also act as "host" plants for animal pests or diseases that may, in turn, affect the desired plants. Finally, weeds are controlled because they often look unsightly.

CAN WEEDS BE TOLERATED?

There is no easy answer to this question. It depends upon what exactly you want out of your garden. Aesthetic considerations aside, most gardens can survive quite healthily with some weeds. The majority only become a real nuisance when they start to take over or if they set seed. The simple rule is the fewer weeds in the garden the better.



Left: *Weed-free plots can be attractive to crop pests. Here, plant collars have been used to prevent root flies attacking the crop.*

GOOD CULTIVATION

The secret of organic weed control is good cultivation. This begins with thorough ground preparation to reduce the build-up of weeds and weed seeds before planting. Fallowing is commonly used to do this. After the ground has been prepared, it is left bare for a period of a few weeks to a few months. The weed seeds are allowed to germinate and are then removed as they appear. This method will never remove all the seeds because they can survive for several years in a dormant state. But the majority of them will have germinated and the task of weed control made easier for the future.

Vigilance is important throughout the growing season, but never more so than in spring and early summer. Tackle weed seedlings as they appear. Some methods of control, such as hoeing, may damage garden plants, so use a hand fork for close work or in areas where hoeing is difficult. A hoe, for example, can sever the roots of surface-rooting shrubs such as rhododendrons. These weeding methods are relatively slow and labour-intensive. The trick is to do it little and often.

Flails, brush cutters, mowers, rollers, burning and other mechanical means are occasionally used. Although strimmers can be used in shrub borders, those that cut using nylon cords can damage woody stems.

MINIMAL CULTIVATION

Many weeds are plants of cultivation, thriving in disturbed ground. Minimal cultivation reduces disturbance and relies on creating a ground-covering layer of vegetation. The plants literally out-compete the weeds, which can be removed as they appear.

COMMON WEEDS

Weeds can be divided into three groups. Annual weeds germinate, grow, flower and set seed in one growing season. Certain annuals, which are known as ephemerals, complete their lifecycle well within this period and can produce several successive generations within the space of one season. The third type of weeds are perennial species. Perennial weeds initially establish from seed, but tend to persist for several seasons, sometimes dying down during adverse seasons only to re-emerge as conditions improve. They are much more difficult to eradicate once established than annual weeds and many are a serious problem in gardens.

Ephemeral and annual weeds

- Annual meadow grass
- Bittercress
- Chickweed

Perennial weeds

- Blackberry (in Australia)
- Couch grass
- Creeping buttercup
- Dock
- Ground elder
- Groundsel
- Nettle



Meadow grass



Chickweed



Creeping buttercup



Dandelion

DIFFERENT TYPES OF MULCH

Mulches provide a physical barrier to weed seeds that would otherwise land on the soil surface. The materials that can be used for mulching are varied in their composition and the effects they have. They are generally classified into synthetic and natural types.


Bark chippings


Newspaper


Dried bracken


Gravel


Old carpet


Sawdust


Woven plastic


Cocoa shells

MULCH

This is a layer of material that is laid over the surface of a soil or other growing medium. While often cited as a means of weed control, applying mulch has other functions that are beneficial to growth. Mulches help to keep the plants' roots warm in winter and cool in summer, greatly assisting new growth in the spring. They also reduce water loss from the soil in two main ways: by shading the soil surface and by slowing down evaporation of water from the soil.

In general, most mulches reduce the number of weeds growing in a planted area. They act by inhibiting the germinating weed seedling from reaching the sunlight or by "drawing up" the weed so that it is spindly and can be easily removed or "pulled". Mulches should be laid on a bare surface, as they will not inhibit established weeds, especially vigorous perennial ones.

If a mulch is laid to an even depth of around 5cm (2in), it will develop a dry dusty surface that will deter the germination of weed seeds that land on it. This is only a temporary measure, but can help reduce weeding at the busiest times of the year.

TIMING AND APPLICATION

Mulches should be laid on warm, moist soil. Autumn is the ideal time, but they can be applied in the spring after the soil has warmed up. Applied too thickly (over 10cm/4in), they may affect water infiltration into the soil. Materials containing an excessive amount of fine humus or soil-like material ("fines") may encourage weed seedlings to establish. In poor-draining soil, mulch may keep the soil waterlogged and this will be detrimental to plant growth. Synthetic materials, especially if they are impermeable such as black plastic, will inhibit oxygen and water infiltration into the soil. Some materials, such as grass clippings, can "pack down" on the surface and form a water-shedding layer.

As mulches encourage surface-rooting, application must be continued once started, otherwise the plants will suffer later. Many ornamental plants, such as rhododendrons, are naturally very shallow-rooting and thus need the protection of mulch for good growth. They benefit from an organic mulch that conserves soil moisture. Some mulches, such as manure and compost, also aid plant development by supplying nutrients.

MULCHING TO CONTROL WEEDS



1 *Grass clippings are a cheap, effective mulch. Apply them at a maximum depth of 5cm (2in) or the heat they create as they decompose may harm the stems. Do not use mowings from grass that has gone to seed.*



2 *Chipped bark should be composted or stored for several months to let it release any resin and start to decompose. Some gardeners worry that it introduces fungal diseases, but the spores are already in the air.*

WATERING

In order to cultivate a successful organic garden, it is crucial to recognize the water requirements of different plants. It is of vital importance that you know when and how to provide the right amount of water as well as how to avoid either drought or waterlogging. Conserving the water in the soil as well as storing and recycling this valuable commodity are of key importance in the organic garden, especially in areas where rainfall is seasonal and droughts are common.



Above: *Water that runs off the roof can be collected in a custom-made rainwater butt, and stored for later use.*

PRINCIPLES OF WATER MANAGEMENT

After rainfall or irrigation, all the soil pore spaces are filled with water. The air is displaced and the soil saturated. If the rain or irrigation were to continue, then surface pooling or runoff would occur. The rate at which a soil can absorb water is influenced by its texture and structure.

Water drains from the soil through the pore system and is replaced to some extent by air. After draining has removed the excess water, the remaining water may be lost either through evaporation or taken up by the plant and lost through its leaves.

All sands and loamy sands tend to have a low available water capacity. Loams and clay have a medium capacity while very fine sandy loam, silt loams, peats and any soil with a high water table have high available water capacity. Clay soils often have a large amount of water within them, but it is held so tightly that plants are not able to obtain it.

WATER AND THE PLANT

All plants are largely made of water and it is critical that water levels are maintained if the plant is to grow and develop. Soft fleshy subjects, such as many bedding plants and some vegetables, use large quantities of water, particularly during establishment. Plants with large leaves or with extensive branch systems, such as large trees, will remove gallons of water from the soil in the course of a hot sunny day.

WATERWISE GARDENING

Since water supplies are limited, we need to do all we can to conserve soil moisture. As the top layer of soil dries out, the dry soil acts as an insulation to further rapid moisture loss. Take advantage of this by avoiding over-cultivation, particularly during the summer, as this may bring moist soil to the surface to dry out. Always try to maintain a well-structured soil and avoid capping (a hard, partially compacted surface layer) as this can prevent the absorption of rainfall by the soil, leaving puddles that quickly evaporate. Mulches help to conserve moisture either by holding water or acting as insulation provided that they are deep enough. Keep the soil surface weed-free and provide shelter from drying winds. Maintain drainage, as poor drainage leads to limited root growth of the plant and poor soil structure.

STORING AND RECYCLING WATER

Water is a precious resource that is sometimes in short supply. Plants in open ground may acclimatize to the soil conditions, but those growing in pots are more susceptible to drought. Mains water can provide an answer but there is a cost involved and supplies can be restricted. Saving water from rainfall or recycling waste water (which is sometimes called "grey water") can overcome the worst ravages of summer drought.

METHODS OF WATERING



1 *When watering by hand, be patient and give the ground around the plant a good soaking. If in doubt, dig a small hole in the soil and check that the water has soaked through to the roots.*



2 *Turning on a sprinkler allows you to leave it and get on with something else. Place a jar under the spray to gauge how much has fallen. There should be at least 2.5cm (1in) of water for the sprinkler to have done any good.*



3 *A spray attached to a garden hose delivers at a greater rate than a sprinkler but it must be held in place until the ground is soaked. It is easy to under-water using this method. Spray the leaves to wash away dirt or dust.*



4 *A seep hose with holes in it is snaked around plants that need to be watered and left in position. When connected, it provides a gradual but steady flow of water that penetrates deeply into the soil.*

AUTOMATIC WATERING SYSTEMS



1 *You can bury a pipeline beneath the surface and plug in various watering devices. A sprinkler can be pushed on to this fitting, which lies flush with the turf.*



2 *Control systems can be fitted to the hose system so that you can alter the pressure of the water. These can also act as a filter.*



3 *Drip-feed systems can be used for beds, borders and containers. "T"-joints allow tubes to be attached for individual drip heads.*



4 *The delivery tube of the garden hose can be held firmly in position with a pipe peg that is inserted into the ground, if this is necessary.*

Storing and recycling household water is a relatively complicated undertaking that is usually best left to specialist contractors. The potential health risks mean that it is not usually wise to store this type of water for any length of time, but it can be used fresh to water non-food plants. Try keeping your bath water and using it to water ornamental plants. It can be used to fill watering cans and is ideal for watering outdoor pot specimens or plants in open ground.

Rainwater may be a viable alternative and some contractors will be able to install large underground tanks to contain seasonal rainfall. The quicker and easier alternative is to install water butts to collect water from downspouts from roof drains. This method will rarely provide enough water for your whole garden, but is often plenty to water (or supplement the watering of) plants in containers, particularly edible plants such as herbs. Rainwater is naturally acidic and is, therefore, not likely to contain many harmful bacteria. Its acidity also makes it the ideal choice for misting plants under glass on hot days (as it will not mark the leaves with lime) and suits many species sensitive to domestic water additives. Rainwater is also a must for people wishing to grow "acid-loving" specimens in pots.

WATERING PLANTS

In areas where seasonal water shortage is a regular problem, choose drought-tolerant species where possible. Seasonal crops (such as vegetables) and displays (summer or spring bedding) tend to suffer the most from drought due to the limited time that they have to develop extensive root systems. If you wish to grow these seasonal plants in drier areas, they will need to be watered regularly to survive prolonged dry periods. Perennials, on the other hand, may actually become more drought-tolerant if they are watered less. This is because they will have to root deeper to find water. Perennials will need to be watered in their first season following planting to ensure their long-term survival. Remember that applying a good drench on a more occasional basis allows the water to penetrate more deeply and have a better long-term effect because it encourages deeper rooting. Watering little and often can prove detrimental in drier climates by encouraging surface roots that may become very drought-prone. After the first growing season following planting, they are better able to cope if not watered at all.

WATERING METHODS

Plants can be watered in many ways, but all generally fall into two categories: hand watering or automatic systems.

Hand watering The commonest "tool" here is the watering can. Numerous designs exist but they all rely upon a gradual delivery through a spout. A rose ensures that a fine spray is delivered that will not wash away soil or damage plants. Hoses can also be used for hand-watering and many nozzles have been designed to deliver a shower of water rather than a jet.

Automated systems There is an array of devices to choose from, some of which can deliver doses of water at set times of the day or week. Even the most complex of these use relatively simple water-delivery methods such as seep or drip hoses and sprinklers. Seep and drip hoses are essentially "leaky pipes" that gradually release water into the soil. Sprinklers shower an area of garden repeatedly until the ground is well soaked. There are many designs for both and the amount of time they need to be left on depends upon the manufacturer's recommendations and the available water pressure. Both hoses and sprinklers offer the benefit of gradual delivery over a large area and both can be operated manually from a mains water supply. A good watering every few days can be extremely beneficial to most plants, especially if recently planted.

WATERING PROBLEMS

These are usually the result of either too much or too little water being applied to the plant. Both over- and under-watering have similar symptoms because both are related to root death. An over-watered plant's root system begins to die off due to a lack of oxygen. The plant becomes short of water and wilts. Other problems can result from the wetting of foliage and flowers. Watering in full sunlight can give plants a scorched appearance, so it is best not to water in hot sunny conditions.

RECYCLING WATER

The suitability of the water left over from washing, bathing and other household activities depends on how much waste matter it contains. Ordinary bath water, for instance, is useful for watering a variety of plants, but the main problem lies in its storage. Waste water always carries the risk of bacterial infestation. Specialist storage methods and filtration can be used, but it is easier to use it immediately (once cooled), and to avoid using it on houseplants or edible crops.

FEEDING

In order for plants to grow and sustain their life processes, they require water and air as well as a range of naturally occurring elements. At least sixteen different elements are needed by all plants for successful growth and development. Three of these elements – carbon, hydrogen and oxygen – are obtained from the carbon dioxide in the air and from the water and oxygen in the soil. In addition to these, plants also need a selection of other important nutrients, which are described here.



Above: *Top-dressing with organic matter provides the soil with nutrients and encourages nutrient cycles.*

IMPORTANT PLANT NUTRIENTS

In addition to carbon, hydrogen and oxygen, plants need other important nutrients, which they obtain directly from the soil or compost. These nutrients are commonly divided into two groups, depending upon whether they are found in plants in high or low concentrations. When they are found in high concentrations and are needed in large amounts, they are known as macro or major nutrients. There are three of these: nitrogen (N), phosphorus (P) and potassium (K). Every organic gardener must be fully aware of the functions of the "essential three". Nitrogen is essentially the shoot and leaf maker and is especially important early in the growing season; phosphorus is important in the formation of roots; and potassium plays a vital role in flower and fruit formation and is also important in promoting hardiness in overwintering plants. Elements that are needed in relatively small amounts are the micro or trace elements, of which there are ten. Among the most important of these are calcium, magnesium and sulphur, although all play a vital role in the growth and development of the plant.

ORGANIC FERTILIZERS

A wide variety of organic substances can boost nutrient levels. They should be used in addition to composts and manures.

Animal manure Bird manure is a good source of nitrogen. Use in pellet form, as the fresh substance will burn plant roots.



Bonemeal

Bonemeal Promotes strong root growth due to its high phosphate content. Use it as a base dressing prior to planting perennials.

Calcified seaweed This raises the pH of the soil and adds calcium, like limestone, but also contains magnesium.



Fish, blood and bone

Fish, blood and bone A general fertilizer that is normally applied in the spring to promote root and shoot growth.

Ground limestone This raises the pH and supplies calcium where there is a deficiency. It is applied as a powder when it is needed.

Gypsum This supplies calcium to soils where there is a deficiency, but does not alter the pH. It is added in a 4:1 ratio to "lighten" clay soils.



Hoof and horn

Hoof and horn This material gives a slow release of nitrogen where strong growth is needed and is applied in the spring or early summer.

Rock phosphate Used mostly to counter phosphate deficiency and as an alternative to bonemeal.

Seaweed meal Helps to build up humus levels in the soil and is used on a wide range of plants.



Calcified seaweed

Wood ash An excellent source of potassium that can be added directly to the soil or to a compost heap.

SYMPTOMS OF DEFICIENCY

Plants exhibit varying symptoms to a nutrient deficiency. General ones are stunted growth, discoloured leaves, including mottling and inter-veinal coloration, and the premature death of leaves or other parts of the plant. Plants may also display twisted or distorted growth as well as poor root growth and development. In many cases, the symptoms are often seen first in the plant's extremities, such as the tips of the shoots, as these are furthest away from the nutrient source. If a plant cannot obtain enough of any nutrient from a soil it will be because there is either little or no nutrient present in the soil, or the nutrient is not "available" to the plant.

Any element can also be toxic to the plant if it is present in sufficiently high amounts or out of balance with other elements in the growing medium.

FEEDING PLANTS ORGANICALLY

Numerous organic nutrient supplements are available. All have their relative advantages, but they should be used only as part of a combined strategy that aims to harness natural nutrient cycles. This usually involves top-dressing the soil with well-rotted organic matter. This is the catalyst to nutrient cycling in the soil as it feeds the

MAKING COMFREY TEA



1 *Cut a large bundle of comfrey leaves from the patch in your garden. Choose good, green, leafy growth. Remove the leaf and stem, but avoid using the crown.*



2 *Place in a plastic container with holes in the base. Weigh down the leaves. Line a second larger container with a plastic bag and place the first container inside. Tie the bag at the top.*



3 *The thick dark liquid from the decomposing comfrey leaves collects in the bag below. The lower bucket allows this to drip down and stores it until the process is complete.*



4 *Decant the finished liquid into a jam jar for later use. The liquid feed must be diluted before it is applied to plants at a ratio of about 10 parts water to 1 part concentrate.*

vast array of soil organisms that naturally make use of essential plant nutrients. The majority of garden composts do not contain especially large amounts of the major plant nutrients; it is their long-term ability to feed soil life that makes them so valuable.

Despite the best intentions, plants can become short of a certain type of nutrient. This is usually avoided by giving the plant a supplement of a "plant food" that is rich in that particular nutrient. This can be applied to the soil as a top-dressing, lightly worked in with a fork, or applied as a foliar feed. Foliar feeding involves spraying a fine mist of a low-strength solution of the feed. The exact concentrations vary according to the feed being used, but a rough guide would be to use a quarter strength of that which you would apply as a liquid feed to the soil. The nutrient will be taken up quickly and the residue is best washed off after a couple of days because any soil-applied fertilizer will have been taken up by then. Applying a weak solution of Epsom salts as a foliar or liquid feed is an example of applying such a tonic.

LIQUID FEEDS AND TEAS

Compost tea is easy to make. Comfrey is ideal for this, but stinging nettles are also very good. You could also use sheep or goat manure, or finely sifted compost from the heap. Simply fill an old pillowcase or burlap bag with your chosen material (comfrey, nettles, compost or manure) and sink it into a large bucket or barrel of water. Cover the container and let it steep for a few days. Remember, the longer you steep, the stronger the tea will be. You may use the final "brew" as a light liquid feed. It can also be used as a foliar feeding medium, provided that it is well diluted. Use the residue in the bag as mulch. An alternative method is shown above.

Worm colonies in containers also produce a liquid feed that is a tonic for your plants. It should be diluted to a ratio of about 10 parts water to 1 part liquid feed. It is generally high in potassium and phosphorus.

OTHER FEEDING METHODS



1 *An alternative method of feeding is to use a liquid feed. This is most useful for plants that are growing in containers. Add the organic fertilizer of your choice to one of the waterings, according to the manufacturer's instructions.*



2 *Organic granular fertilizer can be applied by hand, spreading it over the area covered by the roots below. Follow the manufacturer's instructions. You may wish to protect your hands when applying the fertilizer by wearing a pair of gloves.*



3 *Apply a layer of well-rotted organic material, such as farmyard manure or garden compost, to the surface of the soil around the plant. If the plant is not shallow-rooted, lightly fork the material into the top layer of the soil.*

PLANT NUTRIENTS

The following table highlights the characteristics of the soil nutrients. Symptoms of deficiency may be seen on different parts of the plant at different stages of growth, although it may not always be immediately obvious that a plant is suffering from a nutrient deficiency. Some of the more important symptoms that can be seen on plants are listed below.

PLANT NUTRIENT	NATURAL ORGANIC SOURCE	PLANTS MOST IN NEED	SOILS MOST IN NEED	SIGNS OF SHORTAGE	HOW TO AVOID SHORTAGE	TOXICITY CAUSE
Major plant nutrients						
Nitrogen (N) The "leaf maker"	Bird manure, blood and bone, grass clippings	Grass, vegetables grown for their leaves, and root-bound plants	Sandy soils in rainy areas	Stunted growth; small pale green leaves; weak stems	Apply a base dressing before sowing or planting. Top-dress in spring and summer with organic matter.	Excessive use of nitrogen-rich fertilizer
Phosphates (P_2O_5) The "root maker"	Comfrey, seagrass, horse manure, blood and bone	Young plants, root vegetables, and fruit and seed crops	Sandy soils	Stunted roots and stems; small leaves with a purplish tinge; low fruit yield	Apply a base dressing of bonemeal. Use fish, blood and bone when top-dressing plants.	Excessive use of fertilizer
Potash (K_2O) The "flower and fruit maker"	Comfrey, horse manure, seagrass	Fruit, flowers and potatoes	Sandy soils	Leaf edges turn yellow, then brown; low fruit yield; fruit and flowers poorly coloured	Apply a compound organic fertilizer or wood ash as a base dressing or top-dressing.	Excessive use of fertilizer; lack of magnesium
Minor plant nutrients						
Boron (B)	Beetroot leaves, horse manure, compost, seagrass, untreated sawdust	Root vegetables, top fruit (apples, pears etc.)	Sandy soils	Brown heart (roots); narrow leaves; corky patches on fruit	Top-dress with compost or apply borax in severe cases.	Irrigation water
Calcium (Ca)	Dandelion, lucerne hay, comfrey, horse manure, compost, blood and bone	Fruit, flowers, vegetables	Acid and potash-rich soils	Similar to nitrogen shortage – stunted growth and pale green leaves	Apply lime or use gypsum or calcified seaweed.	High pH causes toxicity for some acid-loving plants
Copper (Cu)	Nettles, yarrow, horse manure, dandelion, chickweed, compost, untreated sawdust	Fruit, vegetables	Sandy soils	Dieback; brown spots on leaves	Top-dress with compost.	Copper-based fungicides
Iron (Fe)	Stinging nettle, compost, dandelion, horse manure, spinach and seaweed	Rhododendrons, azaleas, camellias	Chalky soils	Yellowing of younger leaves	Trouble can occur on chalky, peaty, very light and acid soils. Iron shortage in chalky soils is due to lock-up by calcium and difficult to avoid.	Rare
Magnesium (Mg)	Grass clippings, seagrass	Roses, tomatoes	Sandy, peaty and potash-rich soils	Yellow or brown patches between veins of older leaves	Apply a mulch of compost or Epsom salts if deficiency is severe.	None
Manganese (Mn)	Chickweed, compost, untreated sawdust	Rhododendrons, azaleas, camellias	Chalky soils	Yellowing between the veins of older leaves	Shortage in chalky soils is due to lock-up by calcium (see iron). Acidification for some plants.	None
Molybdenum (Mo)	Cornstalks, compost, grass clippings	Brassicas	Acid soils	Narrow leaves	Apply lime and top-dress with compost.	None
Sodium (Na)	Seaweed	Root vegetables, fruit	Sandy soils	Very rare except in a few seaside-loving plants	Not usually warranted.	Land reclaimed from sea
Sulphur (S)	Cabbage leaves	All plants	Soils in rural areas	Stunted growth and pale green leaves	A light dusting of flowers of sulphur during the year.	Industrial sites and acid rain
Zinc (Zn)	Horse manure, corn stalks, garden compost, untreated sawdust	Fruit, vegetables	Sandy soils	Dieback	Top-dress with compost.	Leaching from containers

BASIC PRUNING

The task of pruning can seem a daunting prospect to some gardeners, but there is, in fact, no great mystery surrounding pruning and a few basic rules are all you need to get started in most cases. At its simplest level, pruning should be regarded as a way of introducing some order to your garden, giving your plants space to grow and look their best, while also controlling them within a set space. The following section provides some basic advice to enable you to prune with confidence.



Above: *Regular dead-heading keeps shrubs tidy and promotes further flowering. Cut flowering stems back to a bud or stem division.*

WHY IS PRUNING NECESSARY?

Pruning is usually carried out to control the growth of stronger subjects that may otherwise damage those of a weaker habit growing alongside; it also ensures plants do not outgrow their allocated space and cause an obstruction. Pruning is also used to train a plant to a specific shape or form; to maintain or improve flowering; and to improve the shape or "balance" of an individual shrub or tree. Finally, it is used to remove dead, damaged, diseased or pest-infected growth. This last type of pruning is referred to as hygienic pruning and helps maintain plant health and vigour.

Constant pruning, however, is not always necessary for the good cultivation of plants. Once a plant has become established and the initial framework has been formed, pruning is often reduced to a minimum. The major exceptions to this include plants that are pruned annually in order to improve flowering, fruiting or quality of foliage. Apples, peaches and other fruit trees and bushes are regularly pruned to increase the yield of fruit. Roses are a good example of an ornamental shrub that benefits from regular pruning, having more vigorous and prolific flowering as a result of cutting back on a yearly basis.

SUCCESSFUL PRUNING

There are arguably two hallmarks of good pruning: a well-planned, careful and methodical approach to the work undertaken and a good working knowledge of the requirements of the plants that are to be pruned. The real results may not always be apparent for months and, in the case of trees, for years.

With secateurs (hand pruners), always try to place the thin blade on the trunk/branch side of the cut. This will result in a short stub and will also prevent a layer of damaged cambium tissue being left immediately under the line of the cut.

GOOD AND BAD PRUNING



1 *A good pruning cut is made just above a strong bud, about 3mm (⅛in) above the bud. It should be a slanting cut, with the higher end above the bud. The bud should generally be outward bound from the plant rather than inward.*



2 *If the stem has buds or leaves opposite each other, make the cut horizontal, about 3mm (⅛in) above the buds.*



3 *Always use a sharp pair of secateurs (hand pruners). Blunt ones will produce a ragged or bruised cut, which is likely to introduce disease into the plant.*



4 *Do not cut too far above a bud. The piece of stem above the bud is likely to die back and the rest of the stem may well die back even further, causing the loss of the whole stem.*



5 *Do not cut too close to the bud otherwise the bud might be damaged by the secateurs or disease might enter. Too close a cut is likely to cause the stem to die back to the next bud.*



6 *It is bad practice to slope the cut towards the bud as this makes the stem above the bud too long, which is likely to cause dieback. It also sheds rain on to the bud, which may cause problems.*

HARD PRUNING SHRUBS



1 *There are a few shrubs – buddleias are the main and most obvious example – which benefit from being cut hard back each spring. This treatment improves the development of the foliage. Elders* (Sambucus) *and the purple smoke bush* (Cotinus) *should also be treated in this way.* Rosa glauca *also responds very well to this type of hard pruning.*



2 *Cut the shoots right back almost to the ground. It is important to ensure that you make the cuts just above an outward-facing bud. Cutting back will leave little more than a stump. It may seem a little drastic, but the shrubs will quickly grow again in the spring. If they are not cut back, they become very leggy and do not make such attractive bushes.*



3 *Several plants that have attractive coloured bark in the winter are best cut to the ground in the spring. So, by the following winter, attractive new shoots will be displayed. The various coloured-stemmed* Rubus, *such as* R. cockburnianus, *as well as some of the dogwoods* (Cornus) *and willow* (Salix), *are good candidates for this treatment.*

Cuts should always be made immediately above a bud and should be done as cleanly as possible. Use well-maintained secateurs that are regularly sharpened. Make sure that you do not position your blade too close to the bud or the tissue that connects the bud to the main plant body could be damaged. As a guide, you should cut 3mm (⅛in) above a bud and always ensure the bud is not damaged when cutting.

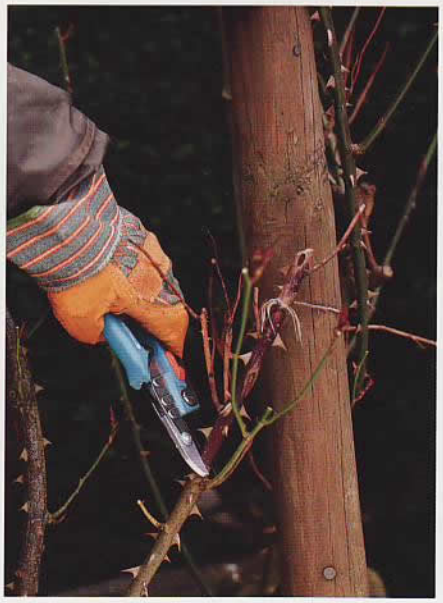
Be careful when using a saw close to a trunk or stem to remove heavier thicker branches. The weight of the branch can sometimes cause splitting and tearing to the main stem wood or bark. These injuries can allow the entry of disease-causing organisms and damage the plant.

The typical order of cuts to follow when pruning any tree is to remember the D's. These are: dead, dying, diseased, displaced or deformed branches. All of these must be removed as the first stage of any pruning work. Then add to this list the C's: criss-crossing branches and crowded growth.

The next stage is to remove any unwanted growth. Care must be applied at this critical stage to ensure that you do not remove too much growth. Finally, once you have cleared this material, it is possible to



Above: *When cutting out crossing stems, cut out the stems while they are still young and free from damage and disease. Using secateurs (hand pruners), cut the stem at its base where it joins the main branch.*



Left: *Tips of stems often die back, especially those that have carried bunches of flowers. Another cause is the young growth at the tip of shoots being killed by frost. If this dieback is not cut out, it can kill off the whole shoot. Even if dieback proceeds no further, the bush looks tidier without these dead shoots. Cut the shoot back into good wood, just above a strong bud.*

PRUNING OUT DEAD WOOD ON A CLIMBER



1 *Most climbers produce a mass of dead wood that has to be removed so that the plant does not become congested. Dead wood is normally quite clearly differentiated from live wood by its colour and lack of flexibility.*



2 *Thin out all of the dead wood that the climber has produced, removing it very carefully in sections, if this is necessary, so that the remaining stems are not damaged when the dead stems are eventually pulled out.*

see what further work needs to be done. Many species have specific pruning requirements, which need to be carried out if the plant is to reach its full potential. Creating balance, form and a pleasing shape in the pruned specimen requires a keen eye, as well as an understanding of the plant's growth habits and tolerances. It is worth taking a little time over this and planning what you are going to do before starting. Acting too hastily now can easily spoil the job. Pruning is one of a few tasks in the garden that are best viewed intermittently from a distance. Remember, you can only cut a branch once. If you cut the wrong branch, you cannot rejoin it effectively to the plant from whence it came. Always check that you know the full extent of a branch and what effect its removal will have prior to making the cut.



Above: *Up to a third of the old wood should be removed to encourage the climber to produce new growth. If possible, cut some of this out to the base; also remove some of the upper stems, cutting them back to a strong growing point.*



Above: *Remove any wood that has become diseased, cutting it back to a point on the stem where the wood of the climber is healthy. If the cut end shows that the wood is still diseased on the inside of the stem, cut back further still.*

PRUNING EQUIPMENT

There is a range of tools that can be used for pruning. It is advisable to use the correct tool for a specific task because it will make the process both easier and more efficient.

Pruning knife Using a pruning knife requires both skill and a sharp blade. A blunt knife can easily damage the plant. Cut away from you and keep hands clear of the direction of the cut.

Secateurs (hand pruners) When small branches are to be removed, it is easiest to use secateurs and remove the branch in one go. Secateurs are the commonest type of pruning tool and are best used on twiggy material up to about the width of a pencil.

Loppers Use these on branches up to 2.5cm (1in) thick. Loppers are useful in situations where secateurs may not easily reach, such as in dense tangled shrubs. Loppers should not be used for very thick branches or they may easily be damaged.

Extension loppers Ideal for cutting out-of-reach branches up to 2.5cm (1in) thick. They are a useful tool but they can be tiring to use and require some practice.

Ratchet and snap cut shears These have three times the power of conventional shears. Used for branches up to 4cm (1½in) in diameter.

Narrow curved Grecian saw Use on branches up to 5cm (2in) in diameter where the branches are very crowded. It cuts on a pulling cut, making its use above shoulder height very easy.

Extension saws These are similar to Grecian pruning but they have an extended handle. They are very useful where larger branches need removing from smaller garden trees.

Bow saw Used for cutting larger branches. Available in various sizes. They cut with a pushing cut, making their use above shoulder height tiring.

PLANT PROPAGATION

Despite the large variety of methods employed, there are really only two basic types of plant propagation: vegetative – taking cuttings, for example – and sowing seed. All of the techniques used fall into one or other of these categories. Raising your own plants is one of the most rewarding activities that any gardener can do. It can also be particularly beneficial for the organic gardener because, unlike with bought-in plants, you can be assured that self-raised stock will be pesticide-free.



Above: *Collecting your own seed can be very rewarding and ensures that your new plants are free of any pesticide residues.*

POTTING MIX FOR PROPAGATION

Seed and cutting potting mix should be almost free of nutrients – the plants do not need soil-derived nutrients until they have rooted. Numerous proprietary brands are available for organic propagation. Alternatively, you can make your own potting mix using finely sifted compost or leaf mould mixed with equal parts of sharp sand or grit. Mixing this is comparatively easy but problems can arise if the organic matter is not thoroughly sterilized. Unless you are able to do this, there is always the possibility of fungal diseases affecting the plants. Worm compost can be good for making potting mix but the easiest way to get sterilized potting mix is to use compost that was made in a hot pile. Use material from near the middle of the pile to get the most sterilized matter.

PROPAGATION FROM SEED

Seeds are nature's way of introducing variety into plant material. Fertilizing the female part of a flower with pollen from the male part produces a seed. Seeds are a resting and survival stage in the plant's life that help it survive adverse conditions in nature. Seeds can survive conditions that kill plants. A seed consists of three things: an embryo (a young plant at its most immature stage); a food supply (to maintain the embryo and provide energy after germination); and a protective seed coat. The embryo consists of a young root system (radicle); the young shoot system (plumule), which carries the seed leaves (cotyledons); and the hypocotyl, which is the junction between the root and shoot systems.

Some seeds need special treatment to germinate. One such treatment is stratification. To stratify seeds, cover them in some damp material, such as damp compost, and keep them in a refrigerator at about 4.5°C (40°F) for up to three months. After this treatment, the seeds are ready to germinate. Seeds that germinate better after stratification are oaks and hellebores.

Seeds require moisture, warmth and oxygen to germinate. Because a seed needs oxygen as well as moisture, it is important not to keep the seeds too wet. On the other hand, the seeds must not dry out. Most seeds germinate best between 18.5–24°C (65–75°F). Most seeds will germinate well in light; however, some seeds, such as those of periwinkle, pansy and verbena, germinate best in the dark.

Many seeds have specific germination requirements that require knowledge of the particular species. Certain generalizations are possible and although it is always advisable to follow the instructions on packets you buy, self-collected seed may require a bit of guesswork. If it is a small dust-like seed (thyme and basil, for example), it probably needs light to germinate. Make sure the seed is well pressed into the moist mixture, but do not cover. Larger seed should be covered to twice its thickness in the soilless mixture. If the seed packet says to scarify, make a scar in the seed by nicking the seed coat in some way. Lightly rubbing the seeds with sandpaper usually accomplishes this. The reason for scarification is to speed up the lengthy process of letting the water past the waterproof seed coat.

MAKING ORGANIC PROPAGATION POTTING MIX



1 *Take equal quantities of an organic material, such as coir or finely sieved leaf mould, and a free-draining material such as vermiculite or perlite.*



2 *Mix the organic material and vermiculite or perlite together thoroughly, ensuring that there are no lumps and that the mixture is open and "free running".*



3 *This organic potting mix for propagation is now ready for use and does not need any additional fertilizer. It can be used to propagate seeds and cuttings.*

SOWING SEEDS IN CONTAINERS



1 *First gather together the basic equipment. You will need pots, potting mix, labels, a pencil, a firming board and a plastic bag.*



2 *Fill the container with the potting mix, gently tapping the pot to ensure that there are no air spaces in the mix.*



3 *Gently firm and flatten the potting mix with the firming board. Take care not to over-firm the potting mix.*



4 *Sow the seed evenly over the potting mix surface. Large seed can be placed, but smaller seed must be scattered.*



5 *With larger seed, lightly cover the seed with finely sieved potting mix. Sieved vermiculite or perlite can also be used.*



6 *Water the pot using a fine rose on a watering can. If the seed is small, water the potting mix prior to sowing.*

VEGETATIVE PROPAGATION

The vegetative parts of the plant (stem, root or leaf) can also be used to produce a new plant. Most fruit trees are propagated asexually, using a bud or a twig from a tree that produces exceptionally good fruit. When this bud or twig becomes an adult tree, it has the same qualities as the "mother" tree. By propagating asexually (cloning), we reproduce the "mother" plant.

PROPAGATING PLANTS FROM SPECIALIZED ORGANS

Plants may be propagated from many different plant parts. Specialized roots, stems and leaves that occur naturally make asexual propagation easy.

Bulb This consists of swollen leaves on a short stem. Bulbs can be propagated by removing small bulblets or offsets that form at the base of the parent bulb. These small bulbs take two or three years to mature into plants that flower. Place offsets in rich light soil. Certain bulbs, such as lilies, can be propagated by removing individual scales from the dormant bulb and placing them in a bag of damp moss. After a few months the scale will develop into a small bulb (a bulbil), which can be potted as if it were a large seed and grown on. Certain lilies (tiger lilies, for instance) produce bulbils in their leaf axils (where the bulb leaf joins the stem) that can also be propagated. Examples of bulbs are tulips, onions and lilies.

Corm This is similar to a bulb and often confused with one. Structurally, however, a corm is different, consisting of a stem that is swollen as a food store. It is shorter and broader than a bulb. The leaves of the stem are modified as thin dry membranes that enclose the corm and protect it against injury and drying. Examples of corms are crocus and gladiolus. The procedure for propagating these is the same as for taking offsets from bulbs.

Rhizome This is a stem that grows horizontally near the soil surface. A rhizome usually stores food, but, as it grows, it develops buds along its length. Rhizomes can be cut into sections with at least one eye or bud. Plants propagated in this way include iris.

Runner This is a stem that arises from a crown bud and creeps over the ground. The plantlet that forms at the tip is easily rooted and forms a new plant. Plants with runners include strawberries and spider plants.

Tuber This is a swollen underground stem or root that stores food. Tuberous plants, such as potatoes and dahlias, can be dug up and the tubers separated. Each section must have a segment of the crown that contains at least one eye or bud.

PROPAGATING TUBERS



1 *Take a sharp knife and cut the tuber (in this case a begonia tuber) through the middle so that each part has a shoot.*



2 *Dust the open cuts with a fungicide such as sulphur or Bordeaux mixture. Prepare two small pots with moist potting mix.*



3 *Plant both halves so that they sit firmly on top of the potting mix. Keep the potting mix moist and plant on when new growth appears.*

ROOT CUTTINGS

To produce a new plant from a root cutting, there must be a shoot bud present or it must be possible for the cutting to form one. The ability of root cuttings to form these buds depends on the time of year. The dormant (resting) season is usually the best time to take root cuttings and it is best to take them from newer root growth.

Make cuttings 3–10cm (1¼–4in) long from roots that are 1–1.5cm (⅜–½in) in diameter. Ensure the roots are from the chosen plant and not neighbouring plants. Cuttings are best taken during the winter, when roots have large carbohydrate supplies, but they may also be taken throughout the growing season. Cut straight through the end of the root closest to the stem. Cut the other end on a slant. This will help you to remember which end is the top (the straight cut) and which is the bottom (the diagonal cut).

Store cuttings from dormant roots for three weeks in moist rooting medium at 5°C (41°F). After this, remove from storage and plant upright in the growing medium. Keep moist and warm in a bright location until the plant has grown large enough to pot on or plant out. This will, of course, vary depending upon the vigour of the plant and slow-growing plants may be best potted up and grown on for a season before finally planting out the following spring.

If root cuttings are taken during active growth, miss out the period of storage and place the cuttings directly in the rooting medium. Phlox and euphorbias are propagated from root cuttings.

STEM CUTTINGS AND LAYERING

Many trees, shrubs and herbaceous plants are propagated from stem cuttings. A root system must be formed on a stem either before or after the stem is removed. Roots can be formed on stems in two ways: by layering and by taking stem cuttings. With layering, the stem is allowed to produce roots before it is cut from the parent plant.

Stem cuttings form roots after the stem is removed. The main difficulty with stem cuttings is keeping the stems alive while they form new roots. Some plant stems root better when the wood is soft and actively growing, others root best from mature wood. Cuttings taken from plants that are actively growing are called softwood cuttings, while those taken after the wood is mature are known as hardwood cuttings.

TAKING ROOT CUTTINGS



1 *Dig up a small section of root from a suitable species with thick fleshy roots. The section must either have a shoot bud or be capable of forming one – in which case the cutting should be taken in the dormant season – if it is to be successful.*



2 *Remove as much of the soil as possible from the root cutting before slicing off the small side roots. Using a sharp knife, remove these as well as dead and damaged portions and any side shoots to leave a section of healthy root.*



3 *Cut the remaining sections of the root into small pieces, approximately 5cm (2in) in length, cutting the bottom end at an angle. Insert the root cutting into propagation potting mix, with the angled end pointing down.*

TAKING HARDWOOD CUTTINGS



1 Select healthy, blemish-free pieces of wood about the thickness of a pencil. Cut each of these into sections about 20–25cm (8–10in) long, angling the top cut.



2 Stand the cut stems in a jar of water until you are ready to plant them out. Ideally, stand the jar in a cool moist place out of direct sunlight.



3 Dig a narrow trench that is deep enough for the cuttings. About 2.5–5cm (1–2in) should emerge above ground. The length of the row will depend on the number of cuttings.



4 Loosely fill the trench to about two-thirds full with sharp sand or fine grit. This is essential as it will allow the passage of air around the bases and prevent rotting off. It will also encourage rooting.



5 Insert the cuttings about 10–15cm (4–6in) apart, making sure that the angled cut is uppermost. If you place any cuttings in upside down – i.e. with the buds facing downward – rooting will not occur.



6 Gently firm the soil, making sure that the cuttings are firm but that the soil surface is not over-compacted. Leave the cuttings for the whole of the growing season before lifting and planting out next winter.

TAKING STEM TIP CUTTINGS



1 Take cuttings from the tips of the stems and put them in a plastic bag. The length of the cuttings will vary, depending on the subject, but take about 10cm (4in).



2 Trim the cuttings to just below a leaf joint and then remove most of the leaves and side shoots, leaving just two at the top. This will help to prevent stem rot.



3 Place up to twelve cuttings in a pot of potting mix that is specially formulated for cuttings or a 50:50 mixture of sharp sand and peat substitute such as coir or leaf mould mix.



4 Water well, and cover with the cut-off base of a soft-drinks bottle, a perfect substitute for a propagator. A heated propagator will speed up the rooting process. Place several pots in the same unit.

Layering is a useful way of increasing some shrubs and climbers that cannot readily be propagated from cuttings. Simple layering is a method of getting a growing shoot to produce roots while it is still attached to the "parent" plant. There are several variations on the technique, and the one you use will depend on the plant and the type of growth it produces.

Softwood cuttings are taken from first-year branches that have not yet become woody. Flowering shrubs are often propagated by softwood cuttings. Late spring and early summer are the best times for success with this method. Take cuttings 5–10cm (2–4in) long. Larger cuttings produce larger plants sooner, but they are prone to more rapid water loss. Make cuts slightly below a leaf node. Remove any leaves on the lower section and insert them into potting mix, making sure that no leaves are touching each other or the potting mix. Remove any cuttings immediately from the tray or pot if they die or appear diseased. Pot healthy cuttings up promptly once they recommence growth following rooting.

Hardwood cuttings are taken once the tissue becomes woody and the plant is dormant. Cuttings can be taken two weeks after leaf fall and before bud burst. Select healthy wood that was produced the previous summer. The wood should be about pencil thickness and cut into sections of approximately 20–25cm (8–10in). Several cuttings can be made from the same branch of some shrubs.

To take hardwood cuttings, make basal cuts just below a node, and upper cuts slightly above a bud. The upper cut should be slanted and the lower cut straight, so that a cutting is less likely to be inserted into the potting mix upside down. Once inserted all the tops of the cuttings should be slanted cuts. Bury cuttings vertically in moist sandy topsoil or sand.

The cuttings should not freeze, but must remain cool. In spring, remove the cuttings from storage and plant in a hotbed or other protected site with exposure to morning sun or filtered light. Leave 2.5–5cm (1–2in) of cutting above ground. Keep cuttings moist until a root system forms. Transplant the cuttings the following spring while they are still dormant.

LAYERING SHRUBS



1 *Choose a stem that will reach the ground without breaking and prepare the soil beneath it. In most cases, the native soil will be satisfactory, but if it is heavy clay, add some potting mix to improve its texture.*



2 *Trim off any side shoots or leaves. Dig a shallow hole and bend the shoot down into it.*



3 *To help hold the shoot in place, peg it down with a piece of bent wire.*



4 *Fill in the hole and cover it with a stone. In many cases, the stone will be sufficient to hold the layer in place and a peg will not be required. The stone will also help to keep the area beneath it moist.*



5 *It may take several months or even years for shrubs that are hard to propagate to layer but, eventually, new shoots will appear and the layer will have rooted. Sever it from its parent and pot it up into a container.*



6 *If the roots are well developed, transfer the layer directly to its new site.*

SIMPLE DIVISION



1 *Water the plant that is to be divided during the previous day. Carefully dig up a clump of the plant using a spade, in this case a Michaelmas daisy (Aster novi-belgii).*



2 *Insert two garden forks back-to-back into the plant and lever apart by pushing the handles together. Keep on dividing until the pieces are of the required size.*



3 *The pieces of the plant can then be replanted in the bed, but dig over the soil first, removing any weeds and adding some well-rotted organic material.*



4 *Alternatively, small pieces of the plant can be potted up individually. After watering, place these in a closed cold frame for a few days before hardening off.*

DIVISION

Division is the cutting or breaking up of a crown or clump of suckers into segments. Each segment must have a bud and some roots to propagate successfully. These segments are replanted and grow into new plants identical to the parent. Most perennials should be lifted and divided when they become overgrown and begin to lose vigour. Vigorous growth in most perennials occurs on the outer segments of the clump. Old growth in the centre of the clump is discarded.

Carefully dig up the plant, loosening the roots and lifting it from the soil. Split apart the main clump with two spades or forks, or chop with a shovel or large knife if the clump is firmly massed. It is advisable to divide autumn-flowering perennials in spring, while those that flower in spring and summer are best divided in autumn.

GRAFTING AND BUDDING

Grafting and budding involve inserting or attaching a part of one plant on to another so that both parts continue to grow. In grafting, you attach a short twig from a desirable variety with two or more buds (called a scion) to a seedling. This seedling is called the stock and forms the root system for the new plant, while the scion becomes the top growth. Budding involves inserting the bud from a desirable variety into a cut or slit in the bark of the stock. The bud develops into the whole top of the plant. You must match scions and buds with stocks according to their ability to grow together.

CHIP BUDDING



1 *Select good bud wood that is free from blemishes and obvious damage, pests or diseases. If you are doing this in the summer, then you must first remove the leaves.*



2 *Remove the bud using a very sharp, flat-edged knife. Cut out the bud with a thin shaving of the wood below the bark and leave a "V" shape at the base.*



3 *Prepare the stock plant by cutting a "church window" shaped notch from the stem that is the same thickness as the chipped bud and leave a small notch cut into the base.*



4 *Place the bud into the notch, fitting the "V"-shaped base into the notch at the base of the "window cut".*



5 *Make sure that the bud fits snugly, with the edges of the bud-wood in contact with the edge of the "window" notch.*



6 *Secure the graft firmly with grafting tape to ensure that the join does not dry out. The graft will usually take in about 4–6 weeks in the summer but winter grafts can take longer.*

THE GREENHOUSE ENVIRONMENT

Greenhouses provide an environment in which levels of light and shade, temperature and moisture, and protection from the elements can be closely controlled and monitored. You can propagate plants to grow outside, protect tender plants from frosts and grow certain crops out of season. A basic understanding of the ways that the greenhouse environment can be controlled will help you on your way to a bumper harvest.



Above: *Shading helps to keep temperatures down in the summer and also protects the plants from sun scorch.*

LIGHT INTENSITY

Natural light has all the right wavelengths that plants need to function and grow successfully. Light intensities vary considerably during the year and gardeners often try to compensate for this by giving extra light to the plant. The quality of this light must be correct for the growth of plants, and light bulbs used to supplement natural light must be of a suitable daylight quality. Natural winter light intensity is often insufficient for certain crops. Conversely, summer light levels, especially when combined with elevated temperatures, can cause problems for other crops. Balanced growth requires good greenhouse design and proper planning for the light requirements of the crop. As a general rule, the ridge that runs along the middle of your greenhouse (if yours is a traditional "A"-shaped one) should always be orientated so that it runs east to west.



Above: *A maximum/minimum thermometer is an essential tool in helping you to judge the conditions in your greenhouse.*

LIGHT READINGS WITH A METER

These should be taken inside the greenhouse and then compared with an outside reading. The difference between the two readings will indicate the percentage of available light transmitted into the greenhouse. A good tip here for those without a professional light meter is to use the automatic aperture reading on an SLR camera or a photographic light meter. It will not give actual figures, but will indicate to a certain extent just how much of the available light is getting through.

ADDITIONAL LIGHTING

Supplementary lighting can be used to "top-up" existing daylight, especially in winter. You should always buy bulbs that give a full spectrum of light (the same quality as daylight – often sold or described as "grow lights"). Almost all bulbs for household use are short of the particular light wavelengths that plants need to produce food and grow successfully. Grow lights tend to use a lot of electricity and it may be cheaper to provide additional light for just a part of the greenhouse, suspending the lights above a crop that really needs the light. Grow lights are available as bulbs or strip lights and can sometimes be bought as special enclosed units.

SHADING

This controls temperature and light. Shading is usually put in place in order to reduce summer temperatures (if they are excessive) or to protect young plants and shade-loving ones from very intense sunlight. Blinds, netting or white shade paint can all be effective.

TEMPERATURE

Almost all plants like a fall in night-time temperature of about 4–6°C (7–10°F) below that in the day. Many commonly grown species have a relatively wide range of tolerances, but most grow best between about 16–24°C (60–76°F). All plants have maximum and minimum temperature tolerances that should never be exceeded.

You can take an average temperature reading inside the greenhouse using a maximum and minimum thermometer. Compare it with one taken outside. You should note, however, that more than just the outside temperature influences that of a greenhouse. The action of the sun, even on a relatively cold day, can result in temperatures being much higher inside than out. Wind is also a factor to consider that can cause a chilling effect far below the temperature average, rapidly cooling the glass and air nearby.

HEATING SYSTEMS

Most heaters depend upon a hotbox or burner. These work by heating the air directly. They are more generally used



Above: *Some automated systems measure air temperature, and then turn on heat and open vents as necessary.*



Left: *Even a relatively small greenhouse can vastly increase the range of plants that you can grow in your garden.*

where there is no need to provide heat on a regular basis – in cold greenhouses, for example, or in polytunnels used for raising early hardy stock. Some enterprising gardeners link hot water pipes to their domestic heating systems to provide heating for the greenhouse. The disadvantage here is that the heat tends to be applied at times to suit the household but not the plants within the greenhouse.

INSULATION

It is possible to insulate a greenhouse by providing additional layers within the structure to trap air. Bubble-wrap plastic is a popular method as it is easy to place in position and allows for the transmission of light. Such methods always reduce the amount of light transmitted, but will save upon heating costs. In addition to this, careful siting of the greenhouse can help to reduce the chilling effects of high winds.

HUMIDITY

Most plants thrive in about 40 to 60 per cent humidity. Plants that are grouped together often set up their own small microclimate where the humidity is higher in the immediate vicinity. Much of the humidity requirement for a plant depends upon where it comes from. Rainforest plants often need 85 per cent or more humidity, whereas cacti need as little as 15 per cent (in cultivation). The humidity is also affected by other factors, notably temperature. Warm air can hold much more moisture than cooler air.

The need to increase humidity rises during the hotter months when it is harder to keep down the temperature in protected structures. Increasing the humidity also helps to slow down the water loss from leaves and may also help to prevent wilting or scorch.

Humidity should be raised by damping down (spraying a hose on hard surfaces, paths or under benches) on hot dry days. If there are only certain plants, such as young seedlings, that require elevated humidity, then these are best covered with a thin layer of clear plastic.

AIR CIRCULATION

All plants need a constant supply of clean fresh air around them in order to grow healthily. Outdoors, normal wind movements would supply this, but in a greenhouse you will need to make provision for this.

Ventilators help control temperature and air flow. Roof vents should normally occupy the equivalent of 15 per cent of the floor space in order to be fully effective. They are normally a single structure that opens "window fashion" with a safety catch to keep them open to the required width. As with greenhouse design in general, there are many designs, most being simple variations on a theme. Side ventilators are also occasionally seen in some greenhouses. These are usually arranged in a "louvre type" fashion, with several overlapping strips that can be opened or closed with a small lever.

CHECKING THE CONDITIONS

The greenhouse microclimate differs from the garden chiefly because the light intensity is lower, the temperature is higher and air turbulence is less. How you modify the environment largely depends on what you intend to grow. Winter salad crops need some additional heat, particularly on cold winter nights. Slightly tender, overwintering perennials may not need any heat unless the temperature drops very low. You must know what the environment will be even on cold winter nights. The only really accurate way to assess the suitability of an environment for plant growth is to take regular readings. Many devices exist to monitor the internal conditions within protected structures. These include thermostats for heating and automatic ventilators, although a seemingly endless array of humidification, automatic shading and watering devices are now available for small greenhouses.

GREENHOUSE HYGIENE

Practising good hygiene is important in maintaining the health of the plants. Dead leaves and debris left lying about can harbour pests and diseases, as can badly affected plants if they are not removed promptly. Once a year, thoroughly clean all surfaces, including glass and glazing bars, with hot soapy water. This will pay dividends during the growing season by reducing the number of annually re-occurring pests and diseases. Where plants are grown in open borders, rotate crops or replace the soil with fresh topsoil every two or three years.



Above: *Bubble-wrap plastic is an ideal material with which to insulate the greenhouse in the winter.*

GREENHOUSE CULTIVATION

In a greenhouse you can hasten the arrival of spring by forcing hyacinths, tulips, azaleas and a whole variety of spring crops. You can also lengthen summer, with roses that bloom far into the autumn, and brighten winter with carnations, camellias and rare tropical flowers. You may also harvest tomatoes in mid-winter and vegetables or greens at any time of the year.



Above: *Early crops and flowers can be raised in pots ready for planting out when the weather is warmer.*

METHODS OF GROWING

Think carefully about how you plan to use your greenhouse and what plants you would like to grow there. The true art of greenhouse gardening lies in using every available area of space. This will involve planning the layout of the growing areas in the greenhouse and making a cropping plan to ensure that you not only use all of the available space, but also every "time space" within the growing calendar.

GROWING IN OPEN GROUND

Many greenhouse plants will grow well in open soil borders. The soil can be prepared in a similar way to that used for borders outside. Remember that much of what benefits outdoor soil (digging and adding organic matter) is also good for indoor soil. The advantage is that the system is sustainable over a long period and can even be serviced as a small raised bed system to help maintain steady soil temperatures. Taller crops, such as tomatoes, are particularly well suited to growing in open borders in the greenhouse, but a whole range of both ornamentals and edible crops can also be grown in this way. Remember that if you intend to grow certain crops indoors – salad crops, tomatoes, legumes or cucumbers, for example – then you may need to rotate these, or in smaller spaces avoid growing them in open ground every second or third year. This is done for the same reasons that outdoor crops are rotated.





Above: *Staging can provide extra space in the greenhouse as well as a comfortable surface on which to work.*

Left: *You can grow crops in soil beds as well as in pots in the greenhouse.*

GROWING IN POTS ON STAGING

Staging is essentially a shelf or shelves on which plants in pots are arranged. It enables the gardener to work at a comfortable height and is particularly useful for those who wish to raise seedlings and propagate plants. The area beneath the staging is somewhat shaded but by no means wasted as it can be used for overwintering dormant plants, growing ferns and other shade-lovers, and for some forms of propagation (lilies propagated from scales, for instance). It also provides the perfect place for propagators and can easily be adapted to become a propagating tent.

USING GROW BAGS

Grow bags offer a good alternative to open beds in smaller greenhouses, where space is limited and no open beds exist. These can be purchased or you can easily make your own by filling a large plastic potting-mix bag with a mixture of garden compost and a little grit. Each bag will support four tomato plants and even greater numbers of smaller plants. Grow bags are ideal for raising sweet peas (*Lathyrus odoratus*) for use on patios or roof gardens where the rich deep soil in which they thrive is unavailable. They can equally be used to raise garden peas or beans.

GROWING CLIMBING PLANTS

The last dimension in the greenhouse is the vertical one, ultimately to the roof. Lean-to greenhouses are especially useful for this, their back walls being well suited for growing such things as vines or kiwi. Even freestanding "apex" houses (those shaped like an "A" with a central ridge) can be used to raise climbing crops, such as cucumbers or melons, to say nothing of the thousands of delightful and colourful ornamental climbers that thrive in the greenhouse.

A YEARLY GREENHOUSE CROPPING PLAN

The plan shown below is a sample of how a greenhouse can be used to be productive all year round. The essential point is that you plan what you want to grow. Once you have decided on this it is a relatively simple matter to make your greenhouse a productive space.

GREENHOUSE TASK	MID-WINTER	LATE WINTER	EARLY SPRING	MID-SPRING
Edible crops	Sow seeds for early crops. Interplant with radishes. Sow early cabbage and cauliflower in pots. Bring strawberries in from frames. Top-dress vines and fruiting climbers.	Sow broad beans. Pot on early vegetable seedlings. Reduce young shoots of vines to one to two per spur and raise lowered rods back to the greenhouse side.	Sow the seeds of Brussels sprouts. Sow indoor tomato seed and make sowings of calendula, tagetes or similar in order to encourage beneficials and pollinators. Prick out seedlings.	Sow seed of outdoor tomatoes, celery, celeriac, melons and cucumbers. Harden off early vegetable plants. Tie new growth from vine rods on to wires. Remove side shoots of early tomatoes.
Ornamentals	Take cuttings of plants such as chrysanthemums. Bring bulb pots in for forcing. Pot on autumn-sown sweet peas into "long" pots.	Start off dahlia cuttings. Cut back and re-pot fuchsias and pelargoniums. Sow sweet peas (*Lathyrus odoratus*). Pot up cuttings of herbaceous plants. Sow herbaceous seed and begin sowing bedding plants.	Harden off early sweet peas. Pot up cuttings and sow seed of half-hardy annuals. Take cuttings. Prick out seedlings. Pot up summer bedding tubers and corms.	Finish sowing half-hardy bedding. Pot up cuttings and prick out seedlings. Make up summer tubs and hanging baskets for growing on.
General	Wash glass panes of greenhouse and frames. Keep conditions on the dry side. Be vigilant for winter pests and diseases. Provide heat as necessary.	Keep an eye on ventilation. Watch for pests and diseases. Keep conditions on the dry side. Remove dead or dying material from plants. Provide heat as necessary and ventilate.	Damp down on hot days and ventilate. Watch for pests and diseases. Begin to feed plants as growth increases. Dig, manure and top-dress borders ready for planting.	Damp down at least twice daily when hot and ventilate. Continue to watch for pests and diseases. Dig borders and manure if you have not already done so.

GREENHOUSE TASK	LATE SPRING	EARLY SUMMER	MID-SUMMER	LATE SUMMER
Edible crops	Plant greenhouse tomatoes into prepared borders or large pots of loam-based potting mix. Interplant with calendula and tagetes to encourage bees into the crop. Prick out celery and celeriac cuttings.	Thin grape trusses using vine scissors. Thin fruit if necessary on peaches growing under glass. Pick tomatoes regularly as they ripen. Pinch out and tie in melons and cucumbers as they reach their intended size.	Hand pollinate melons and cucumbers. Perform last thinning on grape trusses. Feed tomatoes with dried blood to develop uppermost trusses.	Remove lower leaves of tomatoes as fruit ripens. Support melons, removing leaves that shade the fruit. Harvest cucumbers. Sow seeds of winter leaf crops and companion plants.
Ornamentals	Harden off bedding plants. Place winter-flowering cyclamen in shade and allow to partially dry out.	Take cuttings of deciduous shrubs. Propagate houseplants. Sow seeds of spring bedding plants in frames.	Take cuttings of evergreen shrubs and deciduous species. Propagate houseplants. Sow seeds of biennials in frames. Re-start rested cyclamen corms.	Take cuttings of pelargoniums and fuchsias to act as "mother plants" for cuttings the next season.
General	Provide shade over sensitive crops. Feed plants regularly with a liquid "tea". Watch for pests and diseases and introduce biological control.	Water regularly. Continue potting on developing cuttings and seedlings of all plants.	Water regularly (twice daily in hot weather) and damp down two or three times daily to maintain humidity.	Continue potting on developing cuttings and seedlings. Continue to watch for pests and diseases and introduce biological control if necessary.

GREENHOUSE TASK	EARLY AUTUMN	MID-AUTUMN	LATE AUTUMN	EARLY WINTER
Edible crops	Cut melons as soon as they are ripe. Clear tomatoes as they finish.	Plant up winter leaf and salad crops, interplanting these with an appropriate companion planting.	Lift crowns of rhubarb for forcing and leave them on the surface for a week.	Sow seed of early onion varieties. Lift further crowns of rhubarb for forcing. Prune peach trees that are growing under glass.
Ornamentals	Take last semi-ripe cuttings and softwood cuttings.	Harden off spring bedding plants ready for planting.	Move bulbs for forcing into a frame to encourage top growth. Lift and pot up lily-of-the-valley for spring display.	Bring in bulbs for forced flowers. Stool back "mother" plants for early cuttings.
General	Decrease watering as days shorten. Pot on developing cuttings and seedlings of all plants. Remove shading and provide gentle heat on cold nights.	Pot on any remaining cuttings and seedlings. Pick over plants on a regular basis in order to remove dead or dying material. Provide gentle heat on cold nights.	Keep conditions on the dry side. Be vigilant for winter pests and diseases, as plants become more stressed due to low light levels. Provide heat as necessary.	Repair any damage to glass panes immediately it is noticed. Order seed for the coming season if you have not done so already.

COLD FRAMES AND CLOCHES

Individual and multiple plant protectors are useful for covering the transplants or seedlings of warm-weather vegetables or flowers that are set out ahead of the normal planting season. These usually take the form of low plastic tunnels, cloches or individual bell jars. The colder the area in which you live, the greater their usefulness because they effectively extend the length of the normal growing season.



Above: *This is a sturdy brick cold frame with a soil bed for growing winter and early spring vegetables.*

COLD FRAMES

These enable you to sow summer flowers and vegetables some weeks before outdoor planting and may even allow for an extra crop within a season. They are relatively inexpensive, simple structures, providing a favourable environment for growing cool-weather crops in the very early spring, the autumn and even into the winter.

Cold frames have no outside energy requirements, relying on the sun as a source of heat. They collect heat when the sun's rays penetrate the light (the top cover) which is made from plastic, glass or fibreglass. The ideal location for a cold frame is facing the direction of the sun with a slight slope to ensure good drainage and maximum solar absorption. A sheltered spot against a wall or hedge is best. Sink the frame into the ground to provide extra protection, using the earth for insulation. Put a walkway to the front and adequate space behind the frame to help when removing the light.

Designs for cold frames vary. For example, some contain barrels that are painted black and filled with water. These absorb heat during the day and release it at night. Some cold frames are built with a very high back and a steep glass slope. Others are insulated very well and may also include moveable insulation. A simple method of providing insulation is to use sacks filled with leaves over the top of the frame and bales of straw or hay stacked against the sides at night in order to protect against freezing.

There is no standard-sized cold frame. The inside depth of the frame should be determined by the height of the plants that you plan to grow. Spring annuals, perennial seedlings or low over-wintering stock may need as little as a 30cm (12in) backboard and a 20cm (8in) front board. Potted plants may need a 38cm (15in) front board and a 45cm (18in) back board. A standard glass frame light is usually about 1 x 1.8m (3 x 6ft). Do not make the structure too wide for weeding and harvesting; a width of 1.2–1.5m (4–5ft) is convenient to reach across.

Cold frames are useful for hardening-off seedlings that were started indoors or in a greenhouse. This hardening-off period is important because seedlings can suffer serious setbacks if they are moved directly from the warmth and protection of the greenhouse to the garden. It is also possible to start cool-weather crops in the cold frame and either grow them to maturity or transplant them in the garden. Cold frames may also be useful for rooting the cuttings of deciduous and evergreen shrubs and trees, and the softwood cuttings of chrysanthemums, geraniums and fuchsias during the warmer months. Ventilation is most critical in late winter, early spring, and early autumn on clear, sunny days when temperatures may rise above 45°C (113°F). The light should be raised partially to prevent the build-up of extreme temperatures inside the frame. Lower or replace the light early each day in order to conserve some heat for the evening.

In summer, extreme heat and intensive sunlight can damage plants. You can avoid this by shading with a lath (a slatted wooden frame) or old bamboo window blinds. Water plants early so that they dry before dark; this helps to reduce disease problems.



CLOCHES

Traditionally a bell-shaped glass cover, a cloche is a moveable structure that serves as a mini-greenhouse. Cloches can be used to protect transplanted tender plants from spring frosts. They also help to warm up the soil for crops sown directly in the soil.

Left: *When the seedlings are fully acclimatized and ready to be planted out, the lights or lids can be left off altogether.*



Above: *A rigid plastic cloche is easy to use. The sections butt up against each other and can be pegged into the soil. Endpieces are also available.*



Above: *Glass bell jars are simple cloches for covering one plant. They are expensive, but large plastic jars make a good, if not as attractive, alternative.*

The traditional or European cloche is usually built in 60cm (24in) sections that vary in height from 20–60cm (8–24in) and 40–65cm (16–26in) in width. It is made of four panes of glass held together with heavy galvanized wire fittings. It has a handle for ease in carrying and for operating the ventilation system. Several cloches placed end to end make a miniature greenhouse.

Plastic bottles with the bottoms cut out can provide protection for small individual plants. These will last a season or two, but will become brittle over time. Flexible fibreglass sheets held in an inverted "U"-shape by stiff wire hoops or small wooden stakes can be used to cover rows of plants.

A tunnel-like plant protector can be made with a 1.5m (5ft) strip of plastic or fleece laid over 1.8m (6ft) wire hoops placed 1m (3ft) apart. Elastic tiedowns over the top near each hoop will hold the plastic.

Temporary cloches can also be made by arching black, semi-rigid, plastic piping over the row or bed and sticking it into the ground on each side. Lay clear plastic over the arches. If the beds are enclosed with wood, attach brackets to the inside edges of the boxes or sink short pieces of pipe with a larger inside diameter along the sides to hold the arches. The arches can be used to support fleece or shade cloth to ward off both frost and bright sunlight. When this cloche is no longer needed, simply remove the plastic sheet and pipe ribs and store them until the following season.

THE BOTTLE RADIATOR

In areas prone to late air frosts, this simple method can protect outdoor crops such as bush tomatoes. Fill a glass or plastic bottle with water and place it next to the plant. The sunlight will warm the water in the bottle, which will in turn release a gentle heat at night. This is sufficient to prevent cold shock to the plant and will ensure good growth and cropping. It can also be used in conjunction with a fleece covering to enhance the warming effect.





Left: *Old-fashioned cloches are particularly good for decorative vegetable gardens. However, they are also very expensive.*

Far left: *Upturned, clear plastic bottles with the bottoms cut out are ideal for using as mini-cloches, protecting individual plants. This is also an environmentally friendly technique.*

PLANT HEALTH

The main concern for new organic gardeners is that their plants will be attacked by pests and diseases. There is an array of techniques to control these undesirables, although the organic gardener must first learn to recognize signs of distress. However, you are unlikely to experience more than a handful of the problems described, all of which are relatively easy to solve. Pests, for example, are eaten by creatures known as beneficials and so the ecology of the garden, once stabilized, will be enough to keep most problems at bay. There is always a technique to control more persistent problems and so ensure the health of your plants.

Left: *A scarecrow is a traditional way of protecting your crops from marauding birds. It can also be decorative and amusing.*



bove: *Companion plants such as these arigolds can provide welcome colour in e kitchen garden.*



Above: *Brightly coloured flowers can encourage a variety of beneficial insects into your garden.*



Above: *Decorative planting in the vegetable plot can provide additional colour and interest.*

WHY PLANTS GET SICK

Plants are prone to numerous ailments, some of which can be a serious threat to their survival. Pests and diseases are only one of the potential pitfalls that you will meet during a normal growing season. A basic knowledge of the other main factors that can affect plant health are all you will need to help your garden to flourish. While the sight of your plants suffering can be alarming, there are, in general, only a few potential health threats that you are likely to encounter.



Above: *Large blocks of the same type of plant are easy for pests to locate and are therefore prone to attack.*

FROST

This can cause serious problems and is actually more critical than average minimum temperatures. Most harmful are unexpected frosts that can cause severe damage even to hardy subjects, especially when they may have produced "soft" new growth.

While warm air rises, cold air will settle and collect in hollows and depressions. Cold air is laden with water vapour and is therefore heavier. Any valley or low-lying area is, therefore, a potential frost pocket. Cold air will accumulate in a depression and then back up the sloping sides as the build-up increases. Any barrier, such as a hedge or a wall, will obstruct the passage of the cold air and a frost pocket will form. Any plants growing in the vicinity will be exposed to the frost and may be damaged by it.

When the soil is frozen, water is no longer available to the plant and shallow-rooted plants are not able to access any water to replace that which they are losing through transpiration. The plant will dehydrate and the foliage will brown and shrivel. Ground frosts may also cause the soil to "heave" and plants will be lifted out of the ground.

Alternate freezing and thawing is often more damaging to the plant than the initial frost itself, especially for tender or half-hardy subjects such as bedding plants. Severe frost can split the bark on woody subjects and may also distort leaves.

The damage caused by frost is directly related to its duration. A temperature of -4°C (25°F) for one hour may cause little or no damage, while the same temperature for four hours may be disastrous.

WATERLOGGING AND DROUGHT

The build-up of water in the soil, particularly where this occurs over a prolonged period of time, can be highly detrimental to the health of your plants. This is of greatest concern with plants that are not adapted to such waterlogged conditions. As a result, the roots of the plants will suffer and probably die from asphyxiation.



Left: *Planting crops among companion plants will make it more difficult for pests to locate them.*

Water shortage or drought only tends to occur during the summer months when temperatures and light intensity are at their peak. The most obvious sign of the effects of water shortage on a plant is when it wilts and loses its turgidity. Water shortage also causes plant functions to slow down dramatically and prolonged drought can result in permanent cell damage.

WIND

The effects of wind damage to plants, especially woody trees and shrubs, are sometimes only too obvious. Wind often worsens extremes of temperature and drought. In severe cases of wind damage, trees can be broken and shrubs uprooted. The stronger the wind, the more damage is likely to occur.

LIGHT IMBALANCES

A plant's growth is always directed towards the available light. Plants growing in shade often become drawn and etiolated. Conversely, strong sunlight damages plants by scorching the foliage. To prevent such problems it is best to select plants that will grow well in the prevailing site conditions.

NUTRIENT IMBALANCES

Plants exhibit varying symptoms to a nutrient imbalance depending, in general, upon the severity of the problem. Symptoms of deficiency may include stunted growth, discoloured leaves (including mottling and interveinal coloration), the premature death of leaves and parts of the plant, twisted and distorted growth and poor root growth and development.

Right: *A healthy, flourishing border, which is free of pests and diseases, is the ultimate aim of all organic gardeners.*

The symptoms are usually noticed first on the shoot tips, although problems may appear on any part of the plant and in different stages of growth. Determining a cause may involve an analysis of the soil.

Any nutrient can be toxic to the plant if it is present in sufficiently high amounts or is out of balance with other elements in the growing medium.

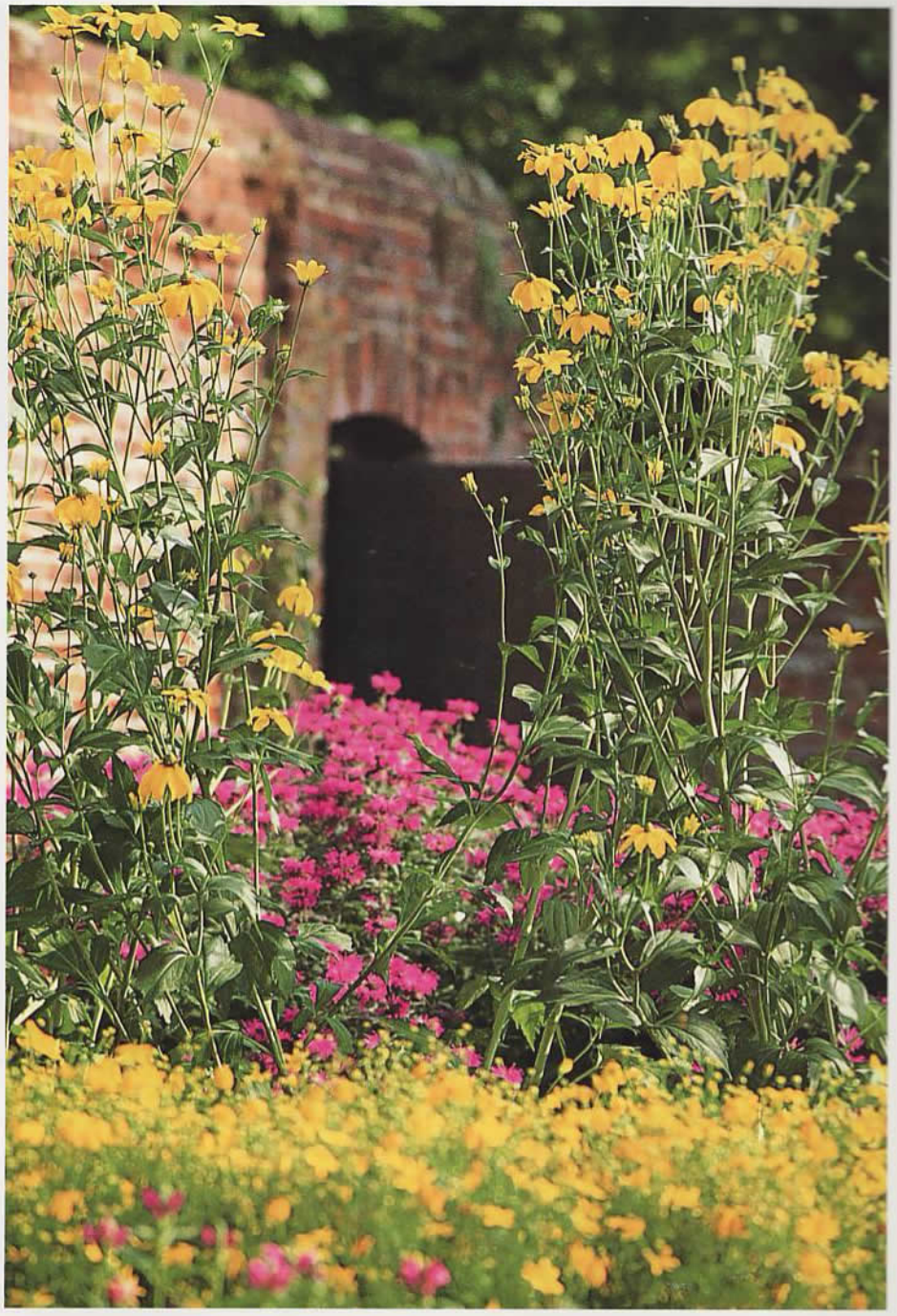
POLLUTION

Specific symptoms of pollution may include leaves turning brown at the tips and margins, leaf discoloration or premature leaf fall. Growth may also be stunted.

Soil pollutant damage can be very severe and rapid in its effects on a plant and its growth. Common problems that you may encounter include extreme soil acidity or alkalinity, chemical toxicity, salt toxicity or pesticide residues. Of these, only soil acidity is relatively easy to cure. If serious pollution is suspected, then this requires specialist help. Such situations, however, are thankfully rare.

PESTS AND DISEASES

It is important to bear in mind that a certain level of pest and disease invasion is normal even on healthy crops. However, it is also true to say that healthy vigorous plants are more resistant to serious attack than plants that are growing under stress. The best form of pest and disease control is obviously prevention. You will need to be able to find and recognize a range of pests and diseases in order to prevent outbreaks of them in your garden and, if necessary, take prompt action.





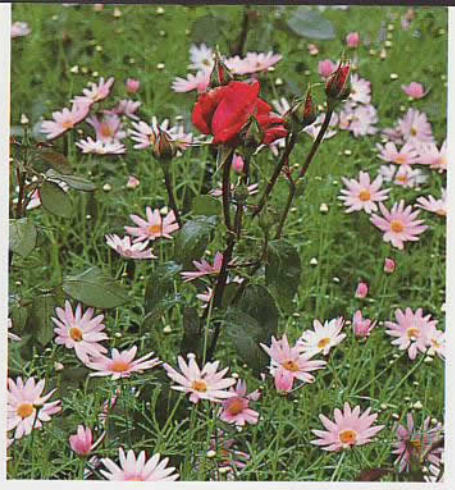
Left: *Healthy plants are often the result of careful selection according to the site conditions.*



Right: *It is very important to recognize potential problems before your plants suffer too much damage.*

PREVENTING PROBLEMS

Organic gardening is about working with nature to create an environment in which plants can withstand attack from pests and diseases, without you resorting to the use of harmful insecticides. If plants become infested with pests or diseases, they may fail to give a good display and crop yields can suffer. Prevention is better than cure, and a keen eye and regular checks will help you to anticipate and prevent the worst of any potential problems.



Above: *A planting combination of roses and daisies will help to attract beneficial predators to the garden.*

GOOD CULTURAL PRACTICE AND HYGIENE

Many pests and diseases can survive without a susceptible host even under the most unfavourable conditions. Myriad plant diseases survive from one growing season to the next on plant debris, in the soil, on seeds or on alternate hosts (some pests and diseases affect different plant species at different times of the year e.g. peach-potato aphid). This means it is vital to remove and properly dispose of any infected plant materials. It is also important for the organic gardener to be aware of the diseases that can threaten an individual crop and recognize the conditions in which these potential threats to plant health can thrive.

GROW DISEASE-RESISTANT CULTIVARS

Plant varieties and cultivars were mostly chosen for other reasons than their disease-resistant qualities. Often they become so commonly grown that their diseases become widespread. Many plants have disease-resistant strains or cultivars, but this does not necessarily guarantee that they will be immune to a disease. However, they will be better able to resist the worst of its ravages.



Above: *Place straw under growing strawberries in order to protect them from rot and soil-dwelling pests.*



Above: *The regular washing down of the glass panes in a greenhouse can reduce the build-up of disease-causing organisms.*

Right: *Regular deadheading of old or damaged blooms will help to reduce the spread of some fungal diseases.*



AVOID PLANT STRESS

A plant that is stressed – by drought or an unfavourable temperature, for example – will be predisposed to pest or disease attack. Plants that are not subjected to higher levels of stress than they can cope with will remain healthy and better able to deal with potential attackers.

Stressed plants often show signs of physical disorders (e.g. being tall, drawn and pale due to lack of light). These can be due to the weather, being wrongly sited, nutrient imbalance or the presence of a toxic substance in the air or soil. Physically stressed plants may become sicker than if a pest- or disease-causing organism actually had invaded them. Stress can kill a plant if the problem is not quickly remedied.

RIGHT PLANT, RIGHT PLACE

Plants all have their preferred locations and the occurrence or lack of a particular environmental factor or factors will ultimately determine whether a plant will prosper in the position in which it has been planted. Ferns, for example, need a cool moist site. Placing one in a hot sunny site will lead to its death as it struggles to keep its moisture. Plants that become stressed will neither grow as well, nor be as disease-resistant, as they would otherwise. Choosing an appropriate site in the first place will at least help to ensure the initial health of your plants and will render them more able to resist other potential threats to their health.

RECOGNIZING THE PROBLEM

Organic gardeners who understand pest life-cycles and behaviour are better able to determine when control will be most effective. Insects living in your garden are all part of nature's complex ecosystems and food chains. Less than one per cent of species that you are likely to encounter are considered pests. Since few insects are actually harmful, organic gardeners must learn which are pests, which are beneficials, and which ones will have no effect on the garden whatsoever.



Left: *Always choose plants that are suited to the site. Alkaline soils – indicated here by the pink flower of this hydrangea – will not suit certain plant species.*

Despite the fact that they are not always popular, insects play an important role in our gardens. Beneficial insects, such as bees, are necessary in the organic garden to pollinate fruit and some vegetable crops. Others, such as springtails, also help to break down dead plant tissue, while wasps and ground beetles capture and eat other pest insects and are called predators. Wasps and midges have larvae that attack pests by living inside their bodies and are called parasitoids. Organic gardeners must learn to cherish this "willing army" of helpers in their gardens.

PEST AND DISEASE CYCLES

Often gardeners believe that their plants have been attacked overnight. This may be true in the case of damping-off disease or with larger pests such as rabbits. More often, however, much has occurred before the symptoms are actually visible.

The pathogen (the pest- or disease-causing organism) must be introduced (inoculated) to the host plant. Most pathogens either move by themselves (as with most pests) or must be carried to the host plant (as with the vast majority of diseases). Rain, wind, insects, birds and people usually spread plant diseases.

Splashing rain carries spores of apple scab fungus from infected apple leaves to uninfected leaves. Wind blows fungal spores from plant to plant, while aphids and whiteflies transmit many common plant diseases. Believe it or not, smokers can transmit tobacco mosaic virus from a cigarette to tomato plants.

Once the pathogen has been transferred to the host plant, it begins to multiply, change or grow into a form that can then enter the host. In many fungal diseases, the pathogen arrives on the plant as a spore, which must germinate before it can begin to grow and invade the plant. Once the fungal spore germinates, it sends out thread-like tubes called hyphae. These penetrate the plant through wounds or natural pores in the outer skin of leaves, stems and roots. The roots of bedding plants that have been damaged during transplanting are a common entry point for root-rotting fungi. A single aphid that lands on a plant can give birth to a clone every twelve hours and can eventually form a small thriving colony within a few days, leaving the gardener with the impression that it suddenly appeared.

Once established, pests or diseases can grow or increase in number and begin damaging plant tissue. As they consume nutrients or plant tissue, evidence of the damage to the plant begins to appear. Symptoms may be seen on any plant parts and include mottling, dwarfing, distortion, discoloration, wilting, shrivelling or holes and notching in the margins of leaves. The first signs of pest infestation may not appear until well after the insect has laid its eggs and disappeared.

Seeds or cuttings from infected plants will also transmit disease. Certified organic seed guarantees that at the time of sale the seeds are free of all diseases. Always try to obtain disease-free stock as this should guarantee that the plant is not infected and will not introduce disease into your garden. This is particularly important with plants such as roses as well as crop plants like raspberries and other small fruits.

Pest insects and mites may carry diseases that infect plants. Organic gardeners use the term "pest management" rather than pest control or pest eradication. It is impossible to eradicate pests from your garden completely. The best option is to try to keep pest numbers low in order to minimize the damage that they can cause in your garden.

ADOPT AN INTEGRATED STRATEGY

Organic gardeners must learn how to use a range of pest management techniques, such as introducing beneficial predators into their gardens (often referred to as biological controls), making gardens less attractive to harmful pests, and encouraging conditions in the garden that favour beneficial predators of all types (cultural controls).



Left: *Composting is the best way of recycling garden waste, but you must never compost material that is diseased.*

PLANT PESTS

Pests can be described as those creatures that harm your garden plants and, if left unchecked, they can quickly cause a great deal of damage. There is a huge army of these pests, but most organic gardeners are unlikely to encounter the vast majority of them. A basic knowledge of the commonest types that occur in domestic gardens is all that you should need to be familiar with in order to protect your plants and guarantee their health and successful growth.



Above: *Pests may well be present before symptoms appear. Close examination may reveal them before the plants start to suffer.*

HOW CAN YOU TELL IF A PEST IS A PROBLEM OR NOT?

Deciding whether a pest is a problem or not is very much a matter of opinion. Commercial growers assess the importance of a pest in terms of their financial losses. Domestic organic gardeners, however, tend to grow fewer plants or crops and mainly grow these for their beauty or for the pleasure of eating home-grown produce. The final decision as to the importance of a pest will rely upon the circumstances and experience of individual gardeners. All organic gardeners must be willing to accept a certain number of pests in their garden as these form part of the intricate food webs that result in natural control. If there are no pests, then the animals that eat them will disappear and open the door to future, potentially serious, pest outbreaks.

RECOGNIZING PESTS

It is important that you are able to accurately identify a pest that has been attacking your plants so that you can take the appropriate action. Just because an insect is seen walking on an affected plant does not mean that it is the one causing the damage. The only real way to control pests involves getting to know them. Many pests produce characteristic symptoms that make it possible to diagnose the cause with relative certainty. Some have a wide range of host plants, and symptoms may not always be as conspicuous on all affected plants. Close examination – perhaps with a hand lens – may be necessary for the final diagnosis. With careful observation and experience, it is possible to keep one step ahead of the pests in your garden.

CONTROL OPTIONS

It is important to control pests before they become a problem. A single black bean aphid (*Aphis fabae*) that lands on a broad bean at the start of the summer could theoretically give rise to 2,000,000,000,000,000 aphids by the start of the autumn. This would be about a million tons of aphids. Numbers such as this are impossible but it does go to show that early control is essential. Quantities such as those quoted in the aphid example cannot occur as the food supply would run out before this can happen. In addition, a whole host of predators eat them. In just a few days, however, pests can cause considerable damage and quick action is needed if you are to save your plants. Organic gardeners must employ a full range of control measures to ensure their plants survive this seasonal invasion, including cultural practices (crop rotation, good hygiene and encouraging biodiversity), physical controls (hand picking, traps, repellents and barriers) and biological control (using other animals that naturally eat pests). These are covered more extensively later in this section but for now it is important to stress that pests can only really be controlled by an integrated strategy that uses a variety of techniques.

CAN PESTS BE TOLERATED?

It is worth pointing out that we tend to be unduly concerned with pests damaging our plants. Supermarkets have conditioned us to expect blemish-free produce. We need to judge the overall health of a plant rather than react when we see a pest. If there were no pests in the garden, then there would be no predators. Step back and look at the whole picture and remember that everything, even pests, has its place in nature. They all add to the interest and diversity that is the most unique quality of an organic garden.



Above: *Birds can be serious pests in the garden. Here, large bites have been taken out of a brassica.*



Above: *Rabbits can devastate a garden overnight, leaving nothing but chewed off stumps as a result of their visit.*



Above: *Although fascinating to watch, squirrels are a garden pest and are closely related to rats.*

COMMON PESTS

There is a seemingly endless array of garden creatures that are waiting to devour and attack your garden plants. The most common pests are almost worldwide in their distribution, but they can be controlled relatively easily. It can be discouraging to see how many potential pests may attack your garden, but it is important to bear in mind that you will only encounter a handful of these in your gardening career.

PEST		PLANTS AT RISK	TREATMENT
Ants and termites		Ants are not really pests, but they "farm" aphids for sticky sugar. Termites can attack some woody species.	Few organic treatments, but baits based on borax are useful. Use a herbal spray of essential oil (citronella and lavender) or lukewarm water as a repellent.
Aphids		Most cultivated plants growing in the open, under glass or indoors.	Encourage beneficial insects to feed on them. Organic insecticidal soap can also be useful, particularly if the aphids are being "farmed" by ants.
Birds		Some birds will attack fruit and brassicas as well as brightly coloured flowers, including blossom.	Bird scarers may be employed as a deterrent and netting will also provide cover for individual crops and plants.
Cabbage root fly		The small maggots grow and develop on and within the roots of the developing cabbage plant.	Place a collar around newly planted seedlings, sinking it into the ground to prevent the newly hatched maggot from reaching the plant roots.
Carrot fly		These root-feeding maggots feed on carrots.	Try companion planting and avoid large monocultures of carrots. Erect plastic or fleece barriers, about 45–50cm (18–20in) high and 2–3m (6½–10ft) apart.
Caterpillars		Many different species of plant, especially those in the cabbage family.	Birds and other predators will reduce populations. Biological control, using a bacterial agent, and pesticides such as derris. Hand-pick off individual plants.
Chafers		Raspberries, strawberries, potatoes, lettuce, young trees, lawns and some herbaceous perennials.	Keep the ground weed-free, and well cultivated in order to reduce the number of bugs. Roll lawns in late spring.
Deer		Browse on garden plants. Male deer rub their antlers against trees, causing damage to the bark.	Notoriously difficult to control, often best kept out by fencing. Repellents are available, based upon formulae such as bear or even lion droppings.
Fruit flies		Troublesome on softer fruits in warm conditions, especially tomatoes.	Cover the fruit with a small piece of rag. Paper bags are also good to use, but can be difficult to get around a truss of tomatoes.
Gall mites and wasps		These pests affect a wide range of trees and shrubs, especially oak trees.	Generally not problematic or life-threatening. They are a good indicator of healthy biodiversity in a garden.
Leaf hoppers		There are many different types, affecting a wide range of plant species.	Difficult to control. Remove dead leaves to reduce overwintering eggs and nymphs. Encourage predators such as lacewings.
Leaf miners		There are many hundreds of species that all have their preferred host species.	Hand-picking of severely affected leaves. Biological controls exist but the problem is rarely serious enough to warrant their artificial introduction.
Leather-jackets		Can be a nuisance, especially of turf grass. They feed on roots just below the soil surface.	Can be difficult to control. Damp sacking over the soil can lure them up to the surface where they can be hand-picked or left for birds to eat.

PEST		PLANTS AT RISK	TREATMENT
Mealy bugs		Suck the sap of many species and produce a sticky honeydew that supports the growth of sooty moulds.	Biological controls are available. Cultural control is more difficult and involves drenching with an organic soap solution and then rinsing.
Mites		A common pest of many plants, especially those growing in hot dry conditions.	Biological controls are available. For a cultural control, improve humidity or spray foliage with an organic soap solution and then rinse.
Moles		Damage roots by lifting small newly planted trees. Tunnel under lawns, making them a serious pest.	Best controlled by trapping or using repellents. Sonic repellent devices are rarely effective. Removing one mole can simply "open the door" to another.
Nematodes (eelworms)		A few species cause disease-like symptoms. A problem when the same plants are grown in the same place.	Regular crop rotations can help to reduce damage. If numbers build up or plants become badly affected, avoid growing the affected species.
Rabbits and hares, squirrels, voles and mice		Rabbits gnaw shoots. Mice and voles eat small bulbs and corms in winter. They all ring-bark young trees.	They may be trapped or a variety of repellents are available. Tree and shrub shelters are useful against voles and mice as is fencing for rabbits and hares.
Sawflies		Developing larvae eat plant tissue. Fruit sawflies are notorious. Slugworm sawfly attack ornamentals.	Control slugworm by applying insecticidal soap. Control fruit sawfly larvae with derris. Both these treatments reduce numbers of beneficial insect predators.
Scale insects		Several species, some of which have specific host plants.	A cultural control consists of swabbing woody stems with a strong organic soap solution or pruning and removing affected parts.
Sciarid fly (fungus gnat)		Tiny flies that feed on soil fungus. The larvae attack the roots of young plants in water-logged potting mix.	Control by preventing the potting mix becoming too wet, although biological controls of nematodes are also available.
Slugs and snails		Common pests of a wide variety of plants. Snails, in particular, cause damage and defoliation of plants.	Often difficult to control although they can be caught in traps containing beer. A variety of barriers and deterrents are also available.
Thrips		Small insects suck the sap of soft foliage and attack flowers. Rarely a problem outside in cooler climates.	Remove seriously damaged foliage. Several natural predators (usually mites) are available for use against thrips.
Weevils		Larvae attack roots, stems or flowers and fruit of a range of plants. Adults feed on affected plants.	Wet acidic composts favour ground-living types such as vine weevil. Biological control possible with parasitic nematodes if temperatures sufficiently high.
Whiteflies		A greenhouse pest in cooler climates that may occur outside in warmer areas.	Biological controls are available but the best option can be to avoid growing susceptible species.
Woodlice (pill bugs)		Usually a pest indoors of crops like cucumbers. May chew through young seedlings.	Often more of an indication of poor hygiene than a problem in itself. A sign that you must clean up the greenhouse.

PLANT DISEASES

The early detection of plant disease can help to halt the widespread infestation of your crop. Try to establish a routine of regularly checking your plants and crops. Look closely for any telltale signs, using a hand lens if necessary. Remember that the first or most obvious symptom may not always be the only one or even the most important. Always check to see if there are other symptoms to ensure that you get the full picture before making your final diagnosis.



Above: *Modern rose varieties are highly susceptible to diseases such as blackspot and mildew.*

RECOGNIZING PLANT DISEASES

Vigilance is the key to success in controlling plant disease. Carefully inspect leaves, stems, roots, flowers and fruits for any sign of disease. You may even find it useful to cut open a branch or stem to look for problems such as discoloration of the tissue, which may explain leaf or stem wilting and sudden wilting of a section of or a whole plant.

Stand back and look at the overall picture. Consider the whole environment. This will include the weather, soil, the stage of development of the plant (and any pathogens present), cultural practices and the condition of other plants in the area. All of this information can help to indicate what may be wrong with the plant. Remember that a plant growing in the wrong location may be stressed.



Try to determine when the symptoms became apparent. The onset of a problem may be due to a cultural practice, the seasonal appearance of a disease or insect, or a weather-related event. Remember that long-term stress is slow to appear, taking a year or more at times.

Try to determine whether the problem is spreading, as this may indicate that it is a disease. Check whether plants of other species have been affected, as diseases are usually (but not always) species-specific. Problems caused by environmental factors do not spread, although the symptoms may become more severe.

You must know what the plant should look like in order to be able to recognize any abnormalities. Reading up a little on the species that you are growing in your garden can help you to make a more accurate diagnosis of the problem.

Remember that there is usually no single cause of a disease infestation. The primary cause may be associated with cultural or environmental conditions. And just as there is probably no single cause, there is usually no single symptom.

When you are attempting to diagnose the cause of plant illness, always inspect symptoms that appear on parts that are still alive (or at least partially alive). Dead plants are often invaded by secondary infestations of decomposer fungi, which may hide the original problem. If possible, make an examination of the entire plant, including roots, although this may not be possible for large specimens such as trees.

Left: *Although a plant may be in obvious distress, closer examination may be needed to properly determine the cause.*

Right: *Disease-causing organisms can enter a plant each time it is cut or pruned.*

CONTROL OPTIONS

Ultimately, where a serious disease is suspected, it may be advisable to avoid growing susceptible species altogether, or, in the case of fruit and vegetables, to rotate the crop as part of a regular cycle. Make notes that provide details on disease occurrence (the type of disease and when it appeared), the plants affected, the weather and environmental conditions in your garden each year. By doing this you can better anticipate what problems are likely to occur in your garden during the growing season.

Finally, remember that even the best gardeners lose plants to disease. This is only serious when large numbers of plants are affected. A diverse garden will contain other highlights, and diseases will claim only a fraction of the planting.



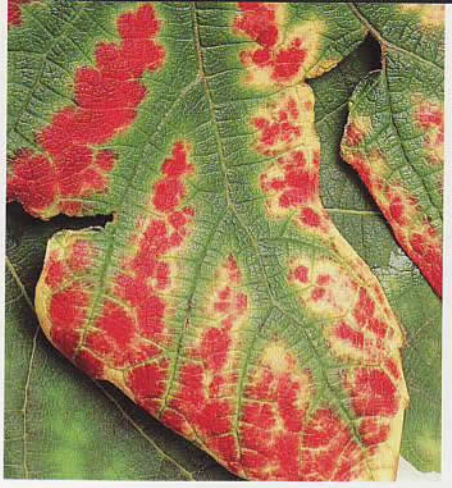
COMMON DISEASES

There are all kinds of diseases that can affect your plants. Most of these are mercifully rare, but every garden will suffer from its share of diseases during the growing season. Most of these conditions are relatively easy to deal with, but a correct diagnosis is essential. As always, it is preferable to try to prevent these diseases taking hold and spreading in the first place rather than treating them when they occur.

DISEASE		PLANTS AT RISK AND THE SYMPTOMS	TREATMENT
Bacterial canker		Many trees and shrubs. Reduces vigour and the rate of growth of the affected plant. Branches become girdled and die back. A sticky secretion will ooze from cracks or welts in the bark.	Difficult to control once a plant is infected. Confine the problem to one specimen by cleaning pruning tools between cuts and before moving on to another specimen of the same type.
Blackspot		A common fungal disease of roses, which is most prevalent on modern hybrid tea and floribunda types. Black spots appear, primarily on the leaves and sometimes on the stems as well.	Prune bush roses into a goblet shape. Use disease-resistant cultivars. Dust affected plants with sulphur early and intermittently throughout the growing season.
Bracket fungus		This disease can affect all types of tree. Bracket fungi are the fruiting bodies of fungi that either parasitize healthy heart wood or, more commonly, decay heart wood that is already dead.	Many affected trees live for many years and need only be felled if they present a risk of collapse.
Common scab of apple		A bacterial disease that causes the formation of large (albeit harmless) scabs on the surface of the apples. Commonly encountered in damp weather and on trees with crowded branches.	Rake up and dispose of affected leaves. Prune out cracked or scabby shoots to remove places for the fungus to overwinter.
Coral spot		A common fungus affecting many woody plant species. Appears as pink or bright red, raised pustules on wood that is showing signs of dieback.	Prune out infected tissue and destroy it. Regular "hygienic pruning" can help to prevent it taking hold in the first place.
Downy mildew		A group of fungal diseases that affects a wide range of plants. Appears as a white coating over leaves that display distended growth, browning and wilting. Thrives in warm moist conditions.	Dust with sulphur or spray with Bordeaux mixture to form a protective barrier against the spores. Note that these are both easily washed off by watering or rain.
Fireblight		Attacks plants of the Rosaceae family, notably apples, pears, plums, cherries, pyracanthas, cotoneasters and roses. The affected plant dies back rapidly from the branch tip.	Remove and destroy all affected material, cutting back to at least 50cm (20in) below the point of infection. Best to remove diseased plants, replacing them with a non-susceptible tree or shrub.
Fungal canker		Affects many woody plants. The bark tissue begins to peel and flake away around the affected tissue in concentric rings.	Prune out the affected material, about 15cm (6in) below the point of infection, and burn it. Clean tools with disinfectant between cuts and especially between pruning individual plants.
Honey fungus		A soil-dwelling fungus that parasitizes the roots of woody plants. Leaves tend to discolour and wilt and fail to develop in the spring. Ultimately, this can weaken and kill the plant.	Difficult to control organically. It may be best to grow herbaceous plants in affected areas for two to three years before attempting to replant woody plants there.
Mosaic virus		This group of viruses affects a very large number of species and is characterized by an irregular, angular mottling or streaking of the leaves.	Winged insects that feed on plants, then migrate to another, can rapidly spread the virus. Control the pests themselves where possible.
Phytophthora		A soil-borne fungal disease that affects many species of woody plants, particularly conifers. Branches die back, often very quickly. Serious infection may cause death for a large proportion of the root system and severe dieback of top growth.	There is no cure for this condition and the removal of badly affected plants may be the only answer. The disease is often restricted to damp or heavy soils, although prolonged wet weather can result in outbreaks.
Powdery mildew		Affects many plant species, with asters being especially prone. The leaves become covered with white powdery patches that may distort growth or even cause leaf drop in severe cases. Thrives in warm, humid or wet conditions.	Sulphur and Bordeaux mixture can provide protection, but these are easily washed off in wet conditions. Avoid growing susceptible species if conditions favour the spread of the disease.
Rust		A common fungal disease affecting many species. Characterized by rusty coloured patches or spots, known as pustules, on leaves. Tissue around the pustules yellows and dies, and this, in turn, may distort growth or cause leaf drop in severe cases.	Commonly seen on soils rich in nitrogen. It may have a noticeable effect on seasonal crops or those grown for their leaves. Bordeaux mixture can reduce its spread but it is difficult to control completely. Avoid susceptible crops and varieties if the problem is persistent.
Silverleaf		Affects both fruiting and ornamental species of *Prunus*. The leaves on some branches gain a silvery sheen, gradually dying back a year or two later. A purple fungal growth appears on the dead tissue.	The affected wood should be pruned out below the point of infection and disposed of in late summer after fruit has set. Badly infected specimens should be removed completely and disposed of, preferably by burning.
Stem rot		Attacks trees and larger woody plants. Stems and branches gradually become hollow.	Smaller trees or shrubs may be much more seriously affected and may be best removed if their condition deteriorates too much.

PLANT DISORDERS

Many external factors can affect garden plants. Weather seldom does what we want it to – there is either too little or too much rain or it is too cold or too hot. If you combine these climatic disappointments with other factors that can affect your plants, such as pollution or nutrient deficiencies, you will see why these difficult conditions can produce a number of disease-like symptoms. They can all put severe stress on an ornamental plant or crop and so precipitate attack from living organisms.



Above: *Nutrient deficiencies can cause discoloration of the leaves. This plant is short of magnesium.*

RECOGNIZING DISORDERS

Plants can be susceptible to a long list of outside forces. Extremes of weather, nutrient deficiencies and physical damage can all take their toll on the health and vigour of a plant. Other environmental factors, such as too much or too little water or pollutants in the soil, can also encourage disease-like symptoms.

Soil pollution can be caused by nutrient deficiency, misapplied fertilizer (resulting in too much nutrient and, therefore, toxicity), spilt lawnmower fuel (perhaps due to careless filling) or buried inert material. Airborne pollution can be more insidious and more difficult to determine or detect.

Weather events such as high winds or frost may go unnoticed if you are not there to witness them. A huge storm will leave evidence in its wake. The effect of a sharp early morning frost, however, or a steady drying wind on a sunny afternoon may not show the damage caused until several days have passed. Often frost occurs in the hours just before daybreak and quickly disappears to leave a fine sunny morning.

Disease can result from a combination of factors, affecting growing conditions and actual disease-causing organisms. Plants may initially be placed under stress – by high winds or frost, for example – making them vulnerable to attack by living agents. For instance, drought may damage roots, which in turn renders them more liable to infection by fungal diseases.

It is important to determine whether the distress that your plant is suffering is the result of a pathogen or due to a problem in the environment. In order to work out which of these is responsible, look to see if the occurrence of ill health is random or uniform in terms of its distribution. As a general rule of thumb, randomly distributed symptoms on injured plants are usually caused by a living factor, such as infectious diseases or a pest. In addition to this, infestations, particularly those caused by diseases, tend to radiate out from central points. Uniform patterns are generally associated with non-living or non-infectious agents such as poisons, fertilizers, environmental stress or mechanical damage.





Above: *Drought is a common cause of stress in potted plants, damaging both roots and shoots.*

CONTROL OPTIONS

If the cause of the problem is physical, you will need to find out whether it is due to a recurring environmental factor inherent in the site, such as constant buffeting by strong winds, or whether it is caused by "one-off" events such as unseasonable frosts or contamination from a careless neighbour's weedkiller spray. Some factors can be removed, such as polluted soil, and windbreaks can be planted and fleece draped over tender specimens on cold nights. If plants continue to be affected, it could be that the plant is in the wrong place and you may have to try it elsewhere.

Left: *Plants sometimes show unusual growth patterns in response to environmental conditions. Here, the growth of a tree has been affected by the wind.*

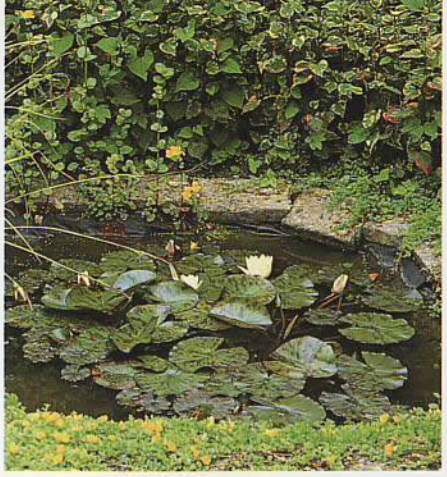
COMMON DISORDERS

Disorders are the result of either an imbalance of essential nutrients or of a range of stresses that are caused by adverse or difficult environmental conditions. Many of the disorders and conditions described here can resemble diseases. This means that is very important for you to diagnose the cause of the distress in the plant before taking any remedial action. A plant disorder will call for a different response to a plant disease.

CONDITION		PROBABLE CAUSE	TREATMENT
Bare patches or areas of poor plant establishment		The patchy establishment of cover crops or turf can be due to soil compaction or underground obstructions. Soil can easily become compacted if it is walked on a lot, particularly when it is wet. Buried obstructions such as rubble can also cause similar growth distortions.	Remove all buried rubble prior to planting or replanting. Relieve compaction by cultivating and replant if required.
Blackening of leaf tips		Usually the result of overwatering, particularly with container-grown plants. The waterlogged soil or potting mix forces oxygen out of the soil, thereby suffocating the roots which suffer a form of drought-stress.	Do not water until the soil or potting mix dries out a little. Check to see if plants need watering before doing so.
Etiolation		Sun-loving plants kept in low light conditions quickly become starved and will be significantly weakened. If kept in these conditions for any length of time, the plant will eventually die.	Choose specimens that are appropriate for the light levels in the garden.
Leaf blackening		Frost damage on buds and leaves in early spring, even to hardy specimens, is usually noticed on new growth that has not yet become acclimatized. It is the sudden shock that often causes the problem, not the actual temperature itself.	Cover slightly tender plants with fleece in the winter. Lightly spray plants with water in the evening to help protect against late frosts.
Leaf scorch		High winds and bright sunlight, especially on shade-loving species. Some plants can also be damaged by watering in bright sunlight, by providing too little or too much water or by applying too much fertilizer to the soil. Hail can also cause leaf spotting or holes.	Water in the evening. Choose wind-resistant species, if appropriate. Apply fertilizer at recommended rates. Do not over- or under-water plants.
Mechanical or physical damage		High winds, which are especially damaging to deciduous woody plants in full leaf. Herbaceous plants can easily break if not adequately staked, as may newly planted trees and shrubs. Snow can snap the branches of conifers and evergreens. Visiting animals can also flatten or snap garden plants.	Stake plants firmly and ensure that animals are excluded from areas where plants could be damaged.
Nutrient deficiency		A lack of or too much of a particular nutrient. Nutrients can also become in short supply if other nutrients are present in large amounts.	Deficiencies are best treated with the application of fertilizer or choose plants that are adapted to deal with the site conditions.
Poisoned ground		Leaked fuel or lubricants used in construction work can leave the ground contaminated. This is usually more of a problem in gardens attached to modern houses. Underground gas pipes can leak, flooding the ground with gas that is lethal to plant roots. Other chemical spillages could come from machinery such as a lawnmower.	Remove all affected soil and replace with fresh topsoil. If pipes are leaking, make sure that they are fixed before replacing soil. Fill lawnmowers with fuel over a plastic sheet.
Root girdling		This can cause instability and the collapse of larger trees and shrubs. Tree and shrub roots become woody following the first year's growth and, if these are constrained in round pots, they tend to grow in spirals.	Try to use bare-rooted stock whenever possible. Tease out roots from the rootball immediately prior to planting.
Wilting		A normal response in many plants to either a lack of water or high temperatures, and not necessarily a cause for great concern. Ligularias habitually wilt on hot summer afternoons, even when planted in wet ground, only to "pick up" and show no ill effects later.	Treatment may not always be necessary. Check the soil first to see if it is dry. If not, wait until the evening to see if the plant shows any signs of improvement.

BENEFICIAL PREDATORS

A thriving population of natural predators and parasites can significantly help to keep pest populations down. The organic gardener must strive to create and maintain an environment in which these welcome visitors to the garden or greenhouse can prosper. Above all, this means avoiding pesticides, which can wipe out beneficial predators and so upset the natural balance in the garden or greenhouse.



Above: *Creating a diverse range of habitats, including a pond, in your garden will encourage beneficial predators.*

BIOLOGICAL CONTROLS

Nearly every species of plant-feeding insect has another insect that is its predator or parasite. Some pests, such as aphids, are eaten by ladybirds (ladybugs), hoverflies and midge larvae, parasitized by wasps and infested by fungal diseases. Large pest populations are a food larder for many "natural enemies", including carnivorous animals, parasites and diseases.

Biological methods of control use these natural enemies of pest insects to keep their populations under control. It is like having an army of insects and other creatures doing the work for you. Biological controls can be encouraged into the garden by creating a suitable habitat. Ironically, this means that the pests must be present first. They must also be present in sufficient numbers to support a viable population of the beneficial predator. This can be a complex area and the easiest way is to encourage the conditions that will favour a balanced food web to develop. Purchasing beneficials is only generally recommended for use in greenhouses although a few (particularly microbes) are suitable for use outdoors.

CREATING SUITABLE HABITATS

The easiest way to achieve this is to get a mixture of habitats. The more variety your garden has, the more biodiversity it will support. Ponds, long grass, log piles, and food plants for animals with varied tastes all encourage a stable garden ecosystem where pests are kept at relatively low levels.

Many birds and bats eat insects. Bats need a roosting site, so place a purpose-made bat box on the shady side of a tree. Position the box at least 3m (10ft) high with a clear airspace in front. Night-scented flowers encourage the moths that bats feed upon. This is the key. The predators must be able to live in your garden or they will go and find a more suitable habitat elsewhere.

The longer you garden organically, the more balance will appear in your garden. This is simply because your garden ecosystem begins to stabilize and diversify over time.



Above: *Log piles encourage beneficial predators such as beetles to colonize and take shelter in your garden.*

BENEFICIAL INSECTS

Predators (those that devour pests directly) and parasitic insects (those whose young hatch inside and devour pests) are often termed "beneficials". Predators include , lacewings and wasps. Parasitic insects (more correctly termed parasitoids) are less well known than predators, but equally effective. They lay their eggs in a pest species. When the eggs hatch, the larvae feed on the pest insect, killing it. The majority of these insects are tiny wasps, although some flies and mites also fall under this category. Learning to recognize beneficial insects is crucial if you want to avoid killing your army of garden helpers.



Above: *Biological controls are a successful way to fight pests. They are mainly used in greenhouses, but others are now becoming available for the open garden. The control insects are released, here from a sachet, in order to attact the pests.*

BENEFICIAL PREDATORS IN THE GARDEN

There are many beneficial predators that will willingly take up residence in your garden and help to control populations of pests in a natural way.

- Anthocorid bug or red kneed capsid
- Bats
- Birds (robin, blue tit and thrush)
- Centipedes
- Earwigs
- Frogs, toads and newts
- Ground beetle
- Harvestman
- Hedgehogs
- Hoverflies
- Lacewings (adult or larva)
- Ladybirds (ladybugs)
- Mites e.g. *Phytoseiulus*
- Nematodes e.g. *Heterorhabditis*
- Parasitic wasps (*Encarsia* or *Aphidoletes*)
- Slow worm
- Spider on web or wolf spider
- Tachinid flies
- Wasps (solitary and social)

BIOLOGICAL CONTROLS IN THE GREENHOUSE OR GARDEN

The application of biological controls in the greenhouse or garden involves using predatory insects or other beneficial animals to control commonly occurring pests. Many pests are only a problem because their natural predators are missing from the garden. Introducing a biological control usually results in the rapid control of the pest.

NAME	PREFERRED TEMPERATURE RANGE	WHAT THEY CONTROL
Amblyseus cucumeris (predatory mite)	25°C (77°F)	The nymphal forms and adults consume large quantities of immature thrips.
Aphidoletes aphidimyza (predatory midge larva)	21°C (70°F); needs 80%+ humidity	Tiny mosquito-like midge larvae that control substantial populations of more than 60 species of aphids.
Cryptolaemus montrouzieri (predatory beetle)	20–25°C (68–77°F); needs 70%+ humidity	This ladybird is effective in controlling mealybugs on houseplants and in greenhouses.
Encarsia formosa (parasitic wasp)	18–25°C (64–77°F)	Minute, flying parasitic wasps, which lay their eggs inside whitefly scales (the pupa stage) and eat them in two to four weeks
Heterorhabditis megidis (parasitic nematode)	Minimum soil temperature of 14°C (57°F). If temperature drops below 20°C (68°F), they become less effective.	Patrol the soil to a depth of about 18cm (7in) and quickly take care of the slow-moving grubs, like vine weevil grubs and chafers. Very effective in pots and containers. Soil must be moist.
Metaphycus helvolus (parasitic wasp)	20–30°C (68–86°F)	These tiny, black and yellow wasps are effective against several soft-scale species, including brown scale. The females lay their eggs under the body of first- and second-stage scales. The grubs feed on scales and develop into adults within two weeks. Adults also provide control by feeding on non-parasitized scales. *Metaphycus* are most effective in semi-tropical conditions.
Phasmarhabditis hermaphrodita (parasitic nematode)	Minimum soil temperature of 5°C (40°F)	Useful for slug control. Should be applied during the early growing stages of vulnerable plants. Needs moist soil.
Phytoseiulus persimilis (predatory mite)	Use once temperature is regularly above 15°C (60°F). Best at 18–25°C (64–77°F); needs 60%+ humidity	Predator mites, slightly larger than the two-spotted mites (also known as red spider mites) upon which they feed.
Steinernema feltiae (parasitic nematode)	Minimum temperature of 10°C (50°F), although they remain effective when the soil temperature drops below this.	Aggressive predators used to control fungus gnats, mushroom flies and leatherjackets. They can be used on lawns as well as in flower and vegetable gardens, fields, orchards and greenhouses.



Above: *Ladybirds (ladybugs) are just one of the many beneficial insects that will help to keep garden pests in check.*

MICROBES

Bacteria, fungi, viruses, protozoans and parasitic nematodes are microorganisms that attack insects. These microscopic hordes are generally effective against very specific pests and present little risk to humans and the environment. Many organic gardeners may well be familiar with a popularly known, microbial-based insecticide known as Bt or *Bacillus thuringiensis*. This commonly available product, which is used to kill many different kinds of moth and butterfly larvae, is a bacterium. It produces a toxin that kills specific caterpillars. The larval pest usually dies within four to seven days. There are many strains of Bt, each type controlling specific pests.

Parasitic nematodes are also very effective against certain pests that live in the soil. However, the nematodes require moist conditions in order to survive and their temperature requirements further limit their use to greenhouses in many cases.

Despite their potential, very few fungi, viruses and protozoa are commercially available because these living organisms are difficult to raise, store and apply. The best way to encourage these willing and tiny helpers into your garden is to maintain a healthy soil that is rich and diverse in terms of the life it contains.



Above: *Providing convenient shelter, such as this lacewing hotel, for beneficial insects can help to increase their numbers.*

OTHER CONTROL METHODS

There are many ways of dealing with the different pests that appear in the garden. Some of these methods have been tried and tested for generations, others are individual to the gardener and are often the result of a happy accident. As an organic gardener, you must learn to use as many different tricks as possible to manage the pests in your garden and to protect your plants.



Above: *Companion plants such as these marigolds confuse or deter pests that would otherwise attack garden plants.*

GOOD GARDENING PRACTICE

The selection and culture of plants can reduce the potential for pests and diseases. Cultural practices are methods the organic gardener can use to change environmental factors that affect plants and their pest populations. It is essential, therefore, that gardeners know the cultural or growing requirements of each plant. Providing the correct conditions results in a vigorous plant that is less likely to be attacked by pests and diseases and can tolerate some damage.



Left: *Slugs and snails are notorious garden pests that are easily kept at bay using a water trap.*

ASSESSING THE DAMAGE

When problems do arise, you must decide whether a pest is causing enough damage to warrant control. In other words, you will need to assess how far the problem can be tolerated before action is necessary. Some form of pest damage is inevitable with any crop, but you will need to establish limits. To do this, you will need to take into consideration the amount of damage that can be tolerated, the numbers of an individual pest that can cause significant damage and the plants' stage of development. The health and vigour of the plant can also have a direct bearing on when or if you need to take action. A few holes on a leaf may not require control, but, if most of the leaf has been eaten, the plant may die.



Above: *Compact discs are an unusual and amusing way of scaring away marauding birds from your crops.*

TAKING ACTION

Monitor your plants to determine when action is necessary. A thorough inspection of the plant allows you to identify a problem before major damage occurs. You should also inspect the plant's entire environment for clues to the problem. Observing and keeping records of weather conditions, for example, can help provide clues to growth patterns and problems.

TYPES OF CONTROL

Control options can be arranged by their mode of action and their impact on the environment. These methods of control can be grouped from least to highest impact: cultural and mechanical controls and "permitted" chemical controls (soaps, oils and botanical insecticides).

Cultural control includes hand removal of larger pests, the use of screens, barriers, and traps, freezing and crushing. These methods generally have little or no negative effect on the environment and are particularly suitable for smaller gardens.

COMPANION PLANTING

This is commonly used to protect plants from pest attack. The theory is that the companion plants – flowers growing next to a food crop, for example – disrupt the searching pattern of the pests looking for host plants. They literally smell these hosts but become confused with the more diverse planting style. Separating rows of cabbages, broccoli or other brassicas with rows of onions has always been a popular

combination, possibly because the onion's strong scent confuses cabbage pests. Tomato plants also grow well next to cabbages and seem to deter caterpillars while growing leeks near carrots repels carrot flies.

SCREENS AND BARRIERS

Any material that is fine enough to keep pests out can be used as a barrier. A variety of screens of different mesh sizes can keep out large insects, birds and rabbits, but they can also prevent pollinating insects from reaching a plant, resulting in lack of fruit. Cardboard and metal collars will prevent cutworms from reaching young transplants. Sticky bands placed on tree trunks trap beetles and soil-hibernating pests. Copper strips are available for slug control. These supposedly react with the slugs' slime to shock them. Sharp particles, such as crushed eggshells, are also used to control slugs.

TRAPS

Certain insect pests can be monitored by using traps. Sticky coloured traps, pheromone traps and pitfall traps (like beer traps for slugs) can all be used to monitor the occurrence of some pests. Whiteflies and aphids are attracted to bright yellow, and this colour is used for sticky cards upon which they become trapped.

You may want to apply a control and then enclose the plants in netting to keep further infestation from occurring – perhaps putting up netting and then releasing predators.

Traps usually serve as a monitoring system, warning of the presence or increase in undesirable pest numbers. Traps can also be useful in timing control measures by showing the presence of migrating or emerging adults. The control measure can then be introduced at the best time to control the particular pest. Codling moth traps for use in orchards are a good example of this. They are sometimes used to control numbers, but most types are limited in their real effectiveness. Yellow, sticky traps attract whiteflies, aphids, thrips, leafhoppers and other small flying insects. Traps that use pheromones or attractive scents to tantalize adult insects are best used as a way to check presence and numbers. Pitfall traps can be cups or jars placed into the ground filled with yeast and water or beer to trap slugs.

WATER

A jet of water from a hose washes aphids, spider mites and other small insects from plant foliage. This must be done frequently since it does not kill insects or eggs and it does not prevent some insects from crawling back on to plants.

INSECTICIDAL SOAPS

These are made from the salts of fatty acids. Fatty acids are components of the fats and oils found in plants and animals. These soaps should not be confused with ordinary cleaning soaps. Insecticidal soaps kill only what they touch and are effective against soft-bodied pests such as aphids, thrips, crawler stage scales, whiteflies, leafhoppers and mites. Insecticidal soaps may cause burning on some plants, particularly those with hairy leaves. Test insecticidal soap on a single leaf if you are unsure – burning will usually occur within 24 hours.



Above: *Birds can be dissuaded from attacking your plants by stretching string and shiny foil over the crops.*

BOTANICAL INSECTICIDES

Derived from plants, botanical insecticides include pyrethrum, citrus oil extracts and the extract of the neem tree. They act rapidly to stop feeding by insects, although they may not kill the pest for hours or days. There are also disadvantages to the use of botanicals. They must be applied frequently, may be difficult to obtain, and, although generally less toxic than many pesticides, they are still toxic and may harm other beneficial garden residents.



Above: *Sticky traps are another form of pest control in greenhouses. Here, pheromones attract pests to the trap where they get stuck. Other traps consist of sheets of plastic covered with a non-drying glue.*

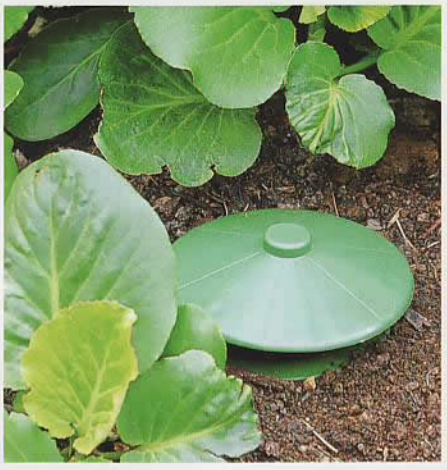


Above: *Horticultural fleece, which is stretched over developing young plants, can provide a physical barrier against smaller pests such as flying insects.*

TRAPS, BARRIERS AND DETERRENTS

The prevention of pest and disease attacks is an essential part of organic gardening. Plants that are infected by pests or diseases are weaker specimens that are difficult to treat and never quite recover their former vigour. Many garden pests can be trapped or kept at bay using relatively inexpensive materials and sometimes recycled household items. Put the barriers in place when the plants are young and always ensure that pests are not trapped inside the barrier.

CONTROL METHOD	HOW IT WORKS
Beer traps and deterrents (granules, copper strips and greasebands)	Traps are effective ways of both controlling pests, such as slugs, and finding out which ones you actually have. Deterrents are physical barriers over which the pest cannot or will not pass. There are many types and their effectiveness can vary.
Bug nets in the greenhouse	Greenhouse vents are problematic in terms of pest control in that they allow both pests in and purchased biological controls out. Bug nets are put in place to avoid this happening.
Fleece on frames	Frames covered in horticultural fleece can be used over outdoor crops to help keep pests out and control the temperature.
Fleece stretched over a crop	Fleece can be used to create a favourable microclimate around young plants. It also acts as a barrier to airborne pests. On the downside, however, it can also keep out airborne predators from pests that overwinter in the soil.
Fruit nets over fruit	Fruit nets are especially useful for summer soft fruit crops that can quickly be devastated by birds.
Individual cloches	Cloches can act as barriers to a wide variety of airborne pests. Any pests that are sealed into this environment may, however, find the perfect environment within which to thrive.
Mesh cages for trees	Mesh cages are usually used to keep rabbits and hares at bay. They are usually simple constructions formed from three or more stakes driven into the ground with chicken wire (or similar) attached to them.
Rabbit fencing	A continuous barrier to prevent rabbits entering areas where plants are growing. The base of the wire should be buried below ground level to prevent the rabbits burrowing a passage beneath it.
Bird scarers (e.g. scarecrows)	Bird scarers have the drawback of a limited lifespan before the birds learn that they are not a real threat. They can, of course, be changed and most bird scarers are only needed on a seasonal basis.
String or wire netting stretched over seedlings (e.g. peas)	Aerial barriers can protect against bird attack. They may only be needed for the duration of the crop's life or even less.
Traps (sticky, coloured traps used in the greenhouse)	Sticky traps can provide a certain degree of control against the flying adults of insect pests. However, they are not as effective as they are sometimes thought to be and are, in fact, of more use for showing whether a particular pest is present or not, thereby allowing appropriate control measures to be put in place.
Traps (pheromone)	Pheromone traps are used to detect the presence of insects. The pheromones attract members of the opposite sex and the appearance of the target species allows you to begin looking for and controlling the young that cause the damage.
Tree guards (spiral)	Spiral guards are useful for protecting the bark of newly planted trees from rabbits and hares, especially in winter and early spring. These guards expand as the tree develops, but they are best removed completely after about a year.
Tree shelter	These protect newly planted trees from vertebrate pests and from the worst rigours of the environment by providing a favourable microclimate around them. They naturally degrade under the action of sunlight, but are best removed after two to three years.
Twiggy branches over plants	Arched over young plants, these can be an effective deterrent to pests such as birds and cats. They do not prevent the migration of beneficial predators to the plants.



Above: *Slugs and snails can be caught in a trap that is filled with stale beer, or water that has been mixed with yeast.*



Above: *Ring tunnels that are covered in a fine mesh will prevent flying insects from attacking your crops.*



Above: *Plastic netting, stretched over the crop and carefully secured, provides an effective barrier against birds.*



Above: *Old plastic bottles make an ideal barrier to protect young plants from pests. These are cheaper than traditional cloches.*



Above: *Chicken wire, stretched over young plants, will prevent birds from reaching and eating them.*

ORGANIC PESTICIDES

While most pesticides are not used in organic gardens, some naturally occurring substances can be used to protect your plants from pests and diseases. The pesticides which you are allowed to use in an organic garden should only be applied when necessary and not on a regular basis.

ORGANIC PESTICIDE	HOW IT WORKS
Bacillus thuringiensis	These are bacterial spores that produce a toxic protein that is useful against caterpillars but will not cause any harm to beneficials. *Bacillus thuringiensis* works quickly, paralysing the caterpillar and so preventing any further damage, although it quickly degrades in sunlight and needs frequent re-application throughout the growing season.
Bordeaux mixture	A compound containing copper and sulphur used to control various fungal diseases including apple scab and potato blight. It is harmful to fish and livestock, and frequent use can lead to a build up of copper in the soil that can be harmful to worms.
Derris	A chemical extracted from the roots of the derris and longocarpus plants. It is useful against a variety of insects including aphids, caterpillars, sawflies and plant-eating beetles. It can prove harmful to beneficials, although it is not a threat to bees.
Insecticidal soap	This is not soap, like the domestic washing soap, but is made from the salts of fatty acids, extracted from plant material. It can be effective against a wide variety of insect pests, although it can damage sensitive plant species.
Plant oils	Their effectiveness varies but most depend upon coming into contact with the pest itself and suffocating it, although some, like neem tree oil, do appear to have insecticidal properties.
Pyrethrum	This organic pesticide is extracted from the flower-heads of *Chrysanthemum cinerariifolium* and is especially effective in controlling aphids. However, it does not persist for long and can also cause harm to beneficial insects.
Sulphur	An effective fungicide against a variety of plant fungi, including powdery mildew, greymould and blackspot. Sulphur can also prove harmful to predatory mites and can cause damage to certain sensitive species.



Above: *Tree shelters and quills protect trees from rabbits and voles, and also provide an ideal growing environment for the tree.*



Above: *Scarecrows are an attractive method of deterring birds and occasionally large pests away from your vegetable garden. They should be moved around the garden and redressed so that the birds do not get too accustomed to them.*

THE ORNAMENTAL GARDEN

Unlike the more fleeting nature of crops in the kitchen garden, the plants in the ornamental garden are usually permanent, which means that a stable ecology may be set up very easily. In fact, lawns, shrubs, trees and flower beds can all be adapted to organic culture. The ornamental garden needs flair and imagination, not only in its design and construction, but also in the types of materials it uses; there is little point in creating an organic garden with materials treated with toxic chemicals and wood that was logged from a tropical rainforest.

Left: *A flower garden in the height of summer provides colour and a natural food source for garden insects.*



Above: *Flowers are like fuel stations for insects, providing them with nectar in return for pollination.*



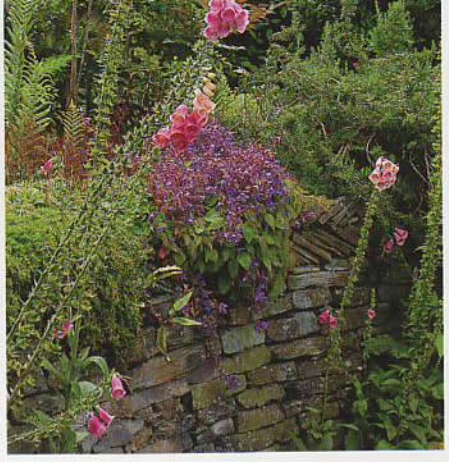
Above: *There is an absolutely staggering range of flower forms in nature, many of which are highly ornamental.*



Above: *Careful selection by gardeners has led to the development of many large and showy varieties of flower.*

THE GARDEN FRAMEWORK

It would be a great shame if we spent a lot of time and effort creating an organic garden, only to find that we had done so at the expense of another habitat or the wider environment. A truly organic approach to gardening should extend beyond the way we grow the plants and maintain the beds and borders to include all the elements of the garden, from the hardscaping materials to the furniture.



Above: *A natural dry-stone wall – assembled without mortar – can quickly become colonized with showy flowers.*

ECOLOGICALLY SOUND MATERIALS

Pictures of logged rainforests, eroded soils and drought-ravaged landscapes are all too familiar. So familiar, in fact, that we run the risk of becoming immune to their shocking truth. Many habitats around the world face increasing pressure from human activities. While there is often little we can do as individuals, we can at least try not to contribute to the demise of such habitats. Rainforests, the source of much of the wood used for garden furniture, are often clear felled, resulting in the loss of much of the biodiversity that they contain.

For this reason, it is important that we use ecologically sound materials. Numerous suppliers claim that they offer ecologically sound products, gathered from sustainable sources. You should check the ecological credentials of the items you buy wherever possible. Buying materials from local sources can help. Always ask who the supplier is, where the materials come from and how their extraction impacts upon the environment. Rocks for alpine gardens, wood for posts and fences, mulch material and potting mixes can all be detrimental to the environment if not carefully sourced.

It is also worth finding out what chemical treatments the material has undergone. Some wood is treated with preservative that may leach out into the soil given time. Potting mixes that are purchased may also contain chemical additives.

Even when products are environmentally sound, it is always worth finding out if the same material (or one that is sufficiently similar) is available from a local source. Transporting materials over great distances, particularly those that are bulky or heavy, involves the use of a considerable amount of fossil fuel. One of the cornerstones of sustainability is to think globally while acting locally. It may even be possible to see the products being made if you do buy from local sources.

Ultimately, of course, the closest source is that which you produce yourself in your own garden. Any organic gardener should, therefore, aim to be as self-sufficient as possible.

PLANTS SUITABLE FOR COPPICING

Most broadleaved trees can be used for coppicing, although some are more suitable than others as the rate of growth varies so widely. In general, most conifers are not suitable for coppicing because they do not readily re-grow from a stump.

PLANT SPECIES	SITE	POTENTIAL USES
Wattle (*Acacia*)	Warm dry situations with good drainage. Especially tolerant of low fertility.	Hurdles and barriers (wattlework). Excellent in warmer climates where other weaving species will not prosper.
Gum (*Eucalyptus*)	Hot dry situations especially where soil is well drained and seasonally dry.	Durable fence posts, stakes and young ornamental growth.
Willow (*Salix*)	Tolerant of wet situations and heavy soils. The roots are notoriously aggressive and may damage nearby drains or foundations.	Weaving work, building and fencing. In a small garden, dogwood is a good substitute for weaving work.
Hazel (*Corylus avellana*)	Any garden soil with good drainage and a pH over 6.5. Tolerates frost, shade, and exposure.	Wattle work, weaving, pea and bean sticks.
Sweet chestnut (*Castanea sativa*)	Light, slightly moist, acid garden soils. Protect from frost and exposure.	Wattlework and fence construction.
Dogwood (*Cornus*)	Most garden soils but dislikes exposure and can sucker aggressively.	Red, orange or lime-green shoots suitable for basketry and other fine rustic weaving work.
Elder (*Sambucus*)	An adaptable species that will thrive in a variety of situations.	Twigs are useful for a number of garden projects and the berries and flowers can be used to make wines and cordials.
Honeysuckle (*Lonicera*)	Likes most soils and thrives with the roots in shade and the topgrowth in full sun.	Stems are a traditional basketry material.

USING RECYCLED MATERIALS

Recycling plays an important role in the organic garden. Waste materials from the kitchen and garden are added to the compost heap; plastic bottles can become mini cloches; and old carpet makes a useful protective cover. Old building materials, such as bricks, slabs, quarried stone and wooden railway sleepers (ties), can all be re-used in the garden.

SUSTAINABLE DESIGN

The more self-sustaining your garden is the better. Gardens that rely heavily upon recycled material – compost, leaf mould and pea sticks, for example – produced within their own confines are naturally self-sustaining. Some external input will always be needed but the garden's long-term success is assured. In short, you will have a sustainable organic garden.

BIO-ENGINEERING YOUR PLOT

This term describes the use of living material to construct the garden framework. It ensures that you make the most of the natural capabilities of some plant species, such as willow, that have been used for centuries for building and fencing. Other examples include using grass for stabilizing soil on slopes or woody plants for hedging. Living barriers do not rot and are self-sustaining.

WILLOW WEAVING



1 *Willow comes in various lengths. The shorter lengths are finest and suited for fine-quality work. This 2.1m (7ft) bundle of "weavers" is the best length for fencing. Thicker uprights are also needed to form the vertical columns to weave around.*



2 *Place the uprights in the ground about 10–20cm (4–8in) apart, ensuring that they are firmly secured. Use a metal spike to make the holes if the ground is hard. The stakes at each end must be the largest and need to be firmly secured.*



3 *Groups of four weavers are used together. Place two in the first gap (between the uprights) and the second pair in the next gap along. Take the back pair of weavers in front of the vertical upright, behind the next upright and to the front again.*



4 *Pick up the other set of weavers and do the same again. Add more weavers as they become thinner and slot these into the uprights to anchor them in. This will give the cross-over effect to the previous weavers.*



5 *Use successive groups of four weavers and continue to weave. Work from the front in order to ensure that the willow fence is neatly finished. Cut off any stubs as you progress.*



6 *At the end of the panel, wrap all four weavers round the post and begin weaving in the other direction. Ensure the weave is tight here and avoid making joins in the weave on the end posts.*



7 *The panels can be solid and used to form a garden boundary. They may also contain spaces, as shown, and act as dividers, while not obstructing the view beyond.*



8 *The finished willow fence will last for many years, especially if it is adorned with climbers such as ivy. Willow fencing encourages wildlife as well as making an attractive feature.*

ORNAMENTAL LAWNS

In spite of the growth in popularity of hard surfaces, such as decking and paving, a well-tended ornamental lawn is still regarded by many as the quintessential feature of a beautiful garden. The lawn provides a safe surface on which children can play as well as an area for relaxing. In the organic garden, the lawn also provides a unique habitat for a wide range of wildlife. There is no reason why you should not have a fully organic lawn that looks pleasing while also contributing to the garden's diversity.



Above: *A well-manicured lawn is the result of regular care and maintenance. Mowing stripes in the lawn is a finishing touch.*

WHAT MAKES A GOOD LAWN?

Some gardeners believe that a good lawn is the product of time, patience and effort, which is true of highly manicured lawns. Others believe that an attractive, but low-maintenance, lawn is the ideal. Neither of these lawns is an impossible dream in the organic garden, but consider whether a lawn can withstand the wear and tear it is likely to receive in a small garden. In this case, it might be better to consider an alternative such as paving or gravel.

You should also consider how much time you are willing to spend maintaining the lawn. Short, highly ornamental lawns need more regular maintenance than longer grass areas, but all lawn areas require some degree of maintenance.

CAN I HAVE AN ORGANIC LAWN?

Lawns, like any community of plants, can be grown quite successfully the organic way. The key to success lies in keeping the grass plants healthy. Lawn grasses are naturally very resilient and competitive plants, well able to withstand a great deal of abuse when they are healthy. Provided they get sufficient light, water, nutrients, air and space, you will be rewarded with an attractive lawn.

TYPES OF LAWN GRASSES

The grasses below, if present in seed mixes or turf, should prosper in the given conditions. Common names of grasses, while frequently used, are not the same in all countries and the Latin names are given as a definitive reference.

Coarse-leaved species
Large-leaved timothy (*Phleum pratense*)
Meadow grass (*Poa pratensis*)
Perennial ryegrass (*Lolium perenne*)
Rough-stalked meadow grass (*Poa trivialis*)
Small-leaved timothy (*Phleum bertolonii*)
Tall fescue (*Festuca arundinacea*)
Wavy hair grass (*Deschampsia flexuosa*)

Drought-tolerant species
Chewing's fescue (*Festuca commutata*)
Hard fescue (*Festuca longifolia*)
Meadow grass (*Poa pratensis*)
Red fescue (*Festuca rubra*)
Sheep's fescue (*Festuca tenuifolia*)
Slender creeping red fescue (*F. rubra litoralis*)

Fine-leaved species
Browntop bent (*Agrostis tenuis*)
Chewing's fescue (*Festuca commutata*)
Hard fescue (*Festuca longifolia*)
Red fescue (*Festuca rubra*)
Sheep's fescue (*Festuca tenuifolia*)
Slender creeping red fescue
(*F. rubra litoralis*)

Shade-tolerant species
Chewing's fescue (*Festuca commutata*)
Hard fescue (*Festuca longifolia*)
Red fescue (*Festuca rubra*)
Wavy hair grass (*Deschampsia flexuosa*)

Species for damp conditions
Large-leaved timothy (*Phleum pratense*)
Rough-stalked meadow grass (*Poa trivialis*)
Small-leaved timothy (*Phleum bertolonii*)

Wear-tolerant species
Browntop bent (*Agrostis tenuis*)
Hard fescue (*Festuca longifolia*)
Sheep's fescue (*Festuca tenuifolia*)
Tall fescue (*Festuca arundinacea*)

CARING FOR AN ORGANIC LAWN

Each grass plant occupies just enough space to grow and closely "knits in" with its neighbours. The taller the plants grow, the lower the number of plants in any one space becomes. As they grow taller, their needs increase and the most competitive plants win. Regular cutting results in a dense coverage with short green leaves and a high number of plants in a given area. The more regularly you cut grass, the more vigorously it grows. Irregular cutting means fewer plants in the area. Less frequent removal of the green material at the top of the plants makes the leaf bases white or yellow and also results in a patchy lawn.

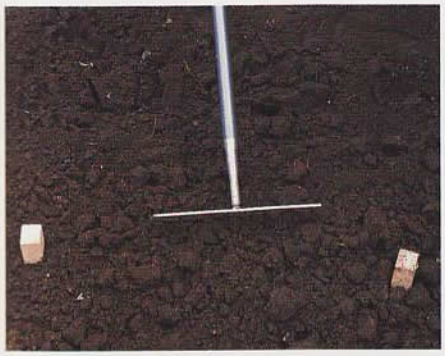
A lawn that is cut regularly will be greener and more attractive than one that is cut more infrequently. In addition, short-cut lawns are an ideal habitat for many garden creatures, particularly birds such as starlings and thrushes. Short grass can even be flower-rich and benefit bees and butterflies.

However, tall grasses favour visiting wildlife and can become an attractive feature in their own right, but they are not ideal for sitting out or for children to play on.

CHOOSING GRASS PLANTS

Once you know what sort of lawn you want, then you must choose the right grass species for your site and what you want to use it for. Some grass species, such as ryegrass, are hardwearing, while others, like the fescues, are drought-tolerant and need less mowing. Trying to grow the wrong grass species for your garden environment will only work if you go to great lengths to tend it and, even then, it will probably be extremely susceptible to damage. Heavy clay soil that becomes wet in winter will not support a close-mown community of fescues, but would be ideal for a ryegrass and bent mixture.

HOW TO SOW A NEW LAWN



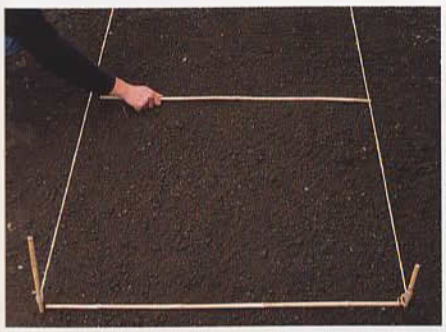
1 *Dig the ground thoroughly, removing deep-rooted perennial weeds. Rake the soil level. Use pegs marked with lines drawn 5cm (2in) down from the top as a guide, having checked with a spirit (carpenter's) level on a straightedge that the pegs are level.*



2 *Allow the soil to settle for a week or so, and then consolidate it further by treading it evenly in order to remove large air pockets. The best method by which to do this is to shuffle your feet methodically over the whole area, first in one direction, then at right angles.*



3 *Rake the consolidated soil in order to produce a fine, crumbly structure that is suitable for sowing seeds. If you can, leave the area for a couple of weeks to allow any weed seeds to germinate. Hoe off the weed seedlings and leave them to die before you apply the grass seed.*



4 *Use string to divide the area into clearly demarcated strips. The strips should be approximately a metre (yard) wide. Divide the strips into squares with bamboo canes or stakes. Move the canes along the strips as you sow.*



5 *Use a small container that holds enough seed for a square metre (yard). Make a mark on it if the amount only partly fills the container. Scatter the seeds as evenly as possible with a sweeping motion of the hand.*



6 *Hire or buy a calibrated granular fertilizer spreader to sow large areas quickly. Check the delivery rates over sheets of paper first and adjust the spreader until the correct amount is being applied per square metre (yard).*

HOW TO LAY A LAWN WITH TURFS



1 *Dig and consolidate the soil as for seed. There is no need to leave it for a few weeks to allow weed seeds to germinate; the turf will prevent them from sprouting. Start by laying the turf along a straightedge.*



2 *Stand on a plank while you lay the next row, as this will distribute your weight. Stagger the joints between rows to create a bond like brickwork. Turf in a long roll will have fewer joints, but these should not align.*



3 *Tamp down each row of turf to eliminate air pockets with the head of a rake, then roll the plank forwards to lay the next row. Brush sandy soil, or a mixture of peat substitute and sand, into the joints to bind the turfs.*

LAWN MAINTENANCE

A rich green lawn is coveted by many gardeners, but a certain amount of maintenance is needed to achieve this. The secret of a healthy and attractive lawn lies in adopting a regular routine. Applying systematic care will also make the lawn relatively easy to maintain. Mowing is the most important and frequent operation carried out, but other practices, including watering, feeding, aerating and top-dressing, will also need to be done to keep your lawn in good condition.



Above: *Mowing will help to keep your lawn both green and healthy but it must be done frequently for the best results.*

MOWING

Where mowing is concerned there is a simple rule that you should always remember. The more grass that you remove by mowing, the more rapid its regrowth will be. The cutting height should be higher during late autumn, winter and early spring when little growth is taking place, but may be lowered in the warmer growing season. Raising the cutting height can also alleviate drought-stress and can help lawns stay green during hot dry summers. As a general rule, you should never remove more than a third of the leaf at any one mowing (unless of course you are cutting down an area left deliberately long for wildlife).

Grass can produce 2–3mm (1/12–1/8in) of growth over a 24-hour period in ideal conditions. The single most important factor is that you should mow regularly. Mowing will need to be less frequent when growth is slow, as in periods of dry or cool weather. Remember that lawns may need cutting in mild periods during the winter.

TURF PROBLEMS

Numerous problems periodically affect turf. The organic approach emphasizes the importance of maintaining strong healthy grass and removing the causes of ill health.

Organic control of turf diseases

- Maintain a vigorous growing sward.
- Control moisture to avoid humid surface conditions, e.g. by brushing.
- Ensure free movement of air.
- Regular aeration treatments.
- Reduce thatch.
- Box off clippings where possible.
- Avoid excessive nitrogen combined with cool conditions (in autumn).
- Avoid lime where possible (test water and top-dressings for lime).
- Adopt a balanced fertilizer regime.
- Sterilize loams and top-dressings.

Organic control of turf weeds

- Aerate to improve surface drainage and enhance grass vigour.
- Hand-dig persistent weeds.
- Mow and collect clippings regularly.
- Scarify the lawn surface.
- Remove earthworm casts.

LAWN CLIPPINGS

Grass clippings contain up to 3% nitrogen, 0.7% phosphorus and 2% potassium by dry weight. Returning clippings directly to the grass surface during mowing promotes the recycling of nutrients and "feeds" the lawn. Clippings also add organic matter to the soil, which will retain water, thus making the lawn more drought-resistant and helping to conserve water. On the downside, grass clippings can make turf more susceptible to disease and soil-borne pests and lead to a build up of "thatch" (a mat of partially decomposed grass leaves above the soil surface). Grass clippings should always be removed if they are excessively thick and will restrict future growth. This is especially true if the grass has not been cut regularly enough.

CONTROLLING THATCH

Thatch is the general term used to describe the layers of organic fibrous material found in turf. It is a perfectly natural component of turf and is desirable to a certain extent because it increases resilience to wear and drought tolerance. Too much thatch, however, can cause an increase in disease, localized dry spots, leaf yellowing, proneness to scalping (during mowing) and a soft spongy surface. It may also affect the tolerance of grass plants to heat, cold and drought.

Top-dressing and avoiding the over-application of nitrogen can help to reduce the build up of thatch, as can liming on acidic soils. Thatch can also be physically removed. This activity is commonly referred to as scarification but is also known as vertical mowing, power-raking or de-thatching. Scarification not only removes thatch, but also removes or controls moss and creeping weeds. It can also help air and



Above: *Grass clippings, leaves and other debris form a thatch at the base of grasses which can stifle them. Remove it with a spring-tine rake. Raking also removes moss.*



Above: *In autumn, rake fallen leaves into piles and scoop them up with a pair of boards. Choose a still day when the leaves are dry to make the job pleasant.*

water to enter the soil. Scarification must only be carried out when the grass is actively growing.

TURF AERATION

Aeration, put simply, means allowing air to get into the soil. In a lawn, it can improve surface drainage, improve soil air supply and relieve compaction. It also makes the lawn more drought-resistant because of improved, deeper grass root growth. Thatch will be reduced due to the increased microbial activity that is the result of better-aerated soil. Improved drainage leads to a warmer soil that will stimulate root growth and will help release unwanted chemicals and gases from the soil.

You should aerate the turf when the soil is moist, but not wet because it will then damage the soil structure. Aerating the lawn when it is too dry can be difficult if the soil is hard. Small areas can be done by hand, with the traditional garden fork proving very effective for relieving localized compaction.

ROLLING THE LAWN

Rolling a lawn gives a smooth, flat and level surface, but it is frequently overdone and invariably leads to soil compaction, loss of structure, poor drainage, poor aeration and reduced root growth. It is important never to roll a lawn when it is wet.

TOP-DRESSING MATERIALS

Numerous materials can be used as bulky top-dressing and each has its own benefits for both soil and grass plants.

Charcoal Sometimes used to improve surface drainage and ventilation.

Garden compost and leaf mould Improves the moisture-holding capacity of a rootzone while being relatively sterile. Often best used in mixtures. Homemade compost should be left for sufficient time to decay. Rich in trace elements.

Sand Porous and compaction-resistant, sand is used as a component for most top-dressing mixes and on its own.

Topsoil Used in "composts" for top-dressing and on its own for fine-turf areas if it contains sufficient sand.

AERATING THE LAWN



1 *Poor grass growth could be because the soil is poorly drained. You can aerate the lawn by pushing the prongs of a fork into the ground.*



2 *Gently brush a soil improver, such as sharp sand or a mixture of soil and sand, into the holes made by the fork.*

TOP-DRESSING THE LAWN



1 *Scatter dry topsoil or top-dressing mix evenly over the surface of the lawn using a shovel. As you throw the shovel outwards in a wide arc, twist it through 180° by rotating the handle. This will help you to spread the mix evenly.*



2 *Using either the flat side of a rake or a stiff broom or besom, work the top-dressing into the surface with short, even strokes. Only apply a top-dressing when the grass is actively growing.*

BRUSHING

Brushing scatters worm casts, grass clippings and other debris on the surface. It also disperses dew and "dries" the surface of the lawn, making it easier to obtain a clean cut with the mower. Frequent brushing can also act as a mild scarifier, lifting the grass blades ready for mowing. Brushing is also used to "work in" bulky top-dressing into the turf surface. A stiff broom or a besom is the most commonly used tool for brushing turf.

TOP-DRESSING

This is the application of a bulky material to the surface of the lawn and usually has no or only minor nutritional value. It is carried out to help level the surface or to improve the nature of the soil. It may also help to reduce the build up of thatch.

Top-dressing should be applied when both it and the surface are dry. It must be thoroughly incorporated into the turf using a brush or besom. Top-dress during the growing season so that the grass has a chance to grow through it and never apply so much that it smothers the grass.

Top-dressing is easier to work into the sward if the area has been mown and scarified first. If it is being carried out as part of autumn renovation work you can mow the area closer than normal. Make sure that you use the same type of material each time you apply top-dressing.

FERTILIZING YOUR LAWN

Organic fertilizers are applied to turf to ensure that there are sufficient nutrients available for healthy, sustained grass growth. The nutrient reserve within the soil is continually being diminished by plant uptake and removal of clippings. Nitrogen is the most important nutrient as it has the most effect upon growth and development. In most situations only nitrogen and potassium will need supplementing by fertilizer application. Most soils have adequate reserves of phosphorus and micronutrients. Organic fertilizers are available as pre-formulated dressings, although fine fertilizers such as fish, blood and bone are quite suitable for early-season application.

Soluble forms of fertilizer (compost teas or worm liquid for instance) should never be applied when grass is not actively growing. The first application of fertilizer in the spring helps to boost grass growth and recovery from winter and quickly improves the appearance of the turf for summer. Closely cut lawns need regular applications every four to six weeks through the growing season. Fertilizer dressing for use in late summer must be low in nitrogen, as an excess will invariably lead to soft growth that is prone to frost damage.

Apply lawn fertilizer evenly over the area to ensure uniform turf grass growth. Poor distribution may lead to scorching in areas that receive too much fertilizer. The best time to apply fertilizer is during a dry interval in a showery weather period when rainfall will wash it into the sward. Water the lawn if there is no rain for 24 hours.



Above: *Feed lawns using an organic fertilizer mix formulated for the season: spring and summer feeds have more nitrogen than autumn ones.*

WATERING LAWNS

Grass becomes dormant during prolonged dry weather. This may lead to invasion by weed species, but the main concern of most gardeners is that the lawn keeps its colour. Raising the height of cut may reduce this problem, but, in prolonged dry periods, the only real solution is to water. Well-aerated lawns often allow the quickest entry of moisture and lose less water to evaporation. Hand watering may be feasible for smaller areas, but it can be time-consuming. If you live in a drought-prone area, the best option is to choose drought-resistant species.

TURF GRASS DISEASES

Fungi cause the majority of diseases. The best way of controlling diseases is to keep the grass growing strongly by choosing the right species for the conditions and ensuring that the lawn is well maintained. Not all turf and soil fungi are harmful, however. Many are beneficial, aiding the decomposition of plant materials and organic matter and so releasing nutrients.

HOW TO REMOVE WEEDS



1 *Use a special weeding tool or knife to prise out weeds. Push the tool in next to the plant and lever out as you pull. Even deep-rooted plants can be removed like this.*



2 *Make any necessary lawn repairs. If you have had to lift a lot of weeds growing close together, leaving a bare patch in your lawn, sprinkle grass seeds over the area.*

HOW TO CREATE A MOWING EDGE



1 *An edge of bricks or paving slabs prevents flowers smothering the lawn. Mark out the area to be lifted, using the paving as a guide. To keep the edge straight, use a half-moon edger. Lift the grass by slicing it with a spade.*



2 *Remove enough soil to allow for the depth of the slab or brick and a few blobs of mortar. Make a firm base by compacting gravel or a mixture of sand and gravel. Use a plank of wood to make sure it is level.*



3 *Bed the edging on mortar for stability. As it will not be taking a heavy weight, just press the slabs on to blobs of mortar and tap level. Lay the slabs evenly and flush with, or very slightly below, the lawn. Check levels.*

REPAIRING A LAWN



1 *Lift the area of damaged turf using a large shovel to beyond the point of wear or damage.*



2 *Cultivate the soil beneath in order to remove compaction or, alternatively, remove all the contaminated soil.*



3 *Add a layer of new, good-quality topsoil using the shovel.*



4 *Lightly firm down the topsoil with the back of a rake.*



5 *Sow grass seed over the newly added soil and gently rake in the seed.*



6 *Water in the seed and keep the patch moist until the new grass is established.*

REMOVING MOSS

Moss readily establishes on areas where grass growth is weak. Moss growth is favoured by a moist surface, mowing too close, surface compaction, shade, low soil fertility and excessive pH. Removing moss is palliative and moss soon returns unless the health of the grass is restored. The best solution is to find the cause and remedy it.

LAWN REPAIRS

There are two methods for repairing turf areas: seeding and turfing. Turf has an instant effect, but seeding is more economical over larger areas. Grass established from seed is usually more hard-wearing.

Repairing with turves Mark out the area and use a half moon and turfing iron or a spade to remove the worn/damaged area of turf. Fork over the soil to relieve surface compaction and add a suitable pre-seeding fertilizer. Firm the area by treading. Rake to obtain a tilth. Lay new turves on prepared soil, ensuring all joints are staggered and leaving the turves about 6mm (¼in) proud of the surrounding area to allow for future soil settlement. Top-dress and ensure the area is irrigated when necessary.

Repairing with seed Mark out the affected area and break up the soil by forking. Rake to produce a suitable tilth and "top up" soil levels if need be. Consolidate the surface by treading and apply a suitable pre-seeding fertilizer. Rake to a tilth and sow the seed in two (or more) directions. Rake in the seed, ensuring the area is level with the surrounding turf. Firm by rolling, if required.

Overseeding This method is used to thicken an existing lawn. Seed is scattered over the lawn, where the seed will then germinate, grow and fill-in the turf surface. Overseeding can be done by hand, broadcasting and scratching in the seed. When overseeding grassy areas, lower seed rates are used than those for new lawns. When soil conditions are dry, ensure that the seed is covered and in contact with the soil underneath. Keep the soil moist until the seed germinates and establishes.

Repairing damaged edges Mark out and lift an area of turf around the damaged edge. Fork over the soil in order to prepare a tilth and relieve surface compaction. Incorporate a suitable pre-seeding fertilizer and firm the area by treading. Rake to obtain a suitable tilth. Re-lay the turf with the damaged edge innermost. Top-dress the newly laid turves, working the top-dressing into the joints. Pay particular attention to the damaged zone. The top-dressing should ideally have a small quantity of seed mixed into it. Alternatively, the area may be overseeded once the turf is laid and top-dressing applied. Ensure the area is irrigated when necessary.



Above: *Insert a half-moon edging tool into the soil. Lever forwards to form a gulley with one vertical side against the lawn and one curved side against the border.*

WOODY PLANTS

Woody plants maintain permanent living structures above ground. They are unique in that their stems repeatedly thicken and strengthen, as is easily seen in the familiar growth rings in wood. Woody plants take many forms: they can be small ground-hugging shrubs or forest giants, and both the largest and oldest living things on our planet today are woody plants. They are the backbone of many gardens, providing height and structure as well as a feeling of permanence.



Above: *Woody plants, such as this flowering quince (*Chaenomeles*), often have very decorative and colourful flowers.*

BUYING WOODY PLANTS

Woody plants may be bought bare-rooted or rootballed, or in containers. All plants should be vigorous, healthy and suitable for the site conditions and intended use. Check that bare-rooted specimens are properly wrapped so as to prevent their roots drying out and ensure that trees and shrubs are free from any obvious pest or disease.

PREPARING THE GROUND

Organic matter is best incorporated across the whole area as a mulch after planting. This encourages the development of a healthy root system. Apply across the whole site during digging if the soil is sandy.

Adding fertilizer is only generally recommended when analysis reveals the soil to be deficient in particular nutrients. Woody plants set up mutually beneficial relationships with soil fungi and gain much of their nutrients as a result of natural nutrient cycles. Often, the best floral displays occur on soils of low fertility, making fertilizer unnecessary.

The key to woody plant growth usually lies in applying organic mulch on an annual basis. Leaf mould is arguably the best substance to use, but well-rotted compost or manure is almost equally useful. An application of bonemeal or similar organic base dressing before mulch is applied can prove to be beneficial when shrubs are newly planted.

PLANTING OUT BARE-ROOTED OR ROOTBALLED TREES

The soil should ideally be moist and friable, not frozen or excessively dry or waterlogged. Bare-rooted or root-balled specimens are usually planted during the dormant season. For deciduous broad-leaved species, this is in winter. An early planting results in better establishment in the following season, and often makes the

PLANTING A SHRUB



1 *Never plant a shrub that is stressed. Before you start planting, check that the plant has been watered. If not, give it a thorough soaking, preferably the night before planting. If this is not possible, ensure that the shrub is watered at least an hour before you plant. This allows the water to be absorbed thoroughly by the potting mix and will help the plant to establish.*



2 *If the soil has not been recently prepared, fork it over, removing any weeds. Add a slow-release fertilizer, such as bonemeal, wearing rubber or vinyl gloves if required, and fork this in.*



3 *Dig a hole wider than the rootball. Put the plant in the hole and check it is deep enough by placing a stick across the top of the pot. It should align with the top of the soil. Adjust the depth of the hole accordingly.*



4 *Remove the plant from its pot, taking care not to disturb the rootball. If it is in a plastic bag, cut away the bag rather than trying to pull it off. Place the shrub in the hole and draw the earth around it. Firm the soil down with the heel of your boot and water in well.*



5 *Finally, mulch all around the shrub, covering the soil with an 8–10cm (3–4in) layer of bark or a similar material. This will not only help to preserve moisture but will also help to prevent any weed seeds from germinating.*

PLANTING A CLIMBER



1 *Dig over the proposed site, loosening the soil and removing any weeds. If the ground has not recently been prepared, work some well-rotted organic material into the soil to improve soil texture and fertility.*



2 *Add a general or specialist shrub fertilizer, if necessary, to the soil at the dose recommended on the packet. Work into the soil around the planting area with a fork. A slow-release organic fertilizer is best.*



3 *Water the plant in the pot. Dig a hole that is much wider than the rootball. The hole should be at least 30cm (12in) from the wall or fence. The free-standing canes will be angled towards the wall or fence.*



4 *Stand the plant in its hole and place a cane across the hole to check that it is at the same level. Take the plant from the pot or cut the bag away. Holding the plant steady, fill in the soil. Firm as you go with your hands.*



5 *Train the stems up individual canes. Tie in with string or plastic ties. Even twining plants or plants with tendrils will need this help. Spread them out, so that they will ultimately cover the whole of their support.*



6 *Water the climber thoroughly. Put a layer of mulch around the plant to help preserve the moisture and prevent weed growth. Do not pile mulch up against the stems of the climber, however.*

plants more resistant to spring drought. Evergreen specimens establish more readily if planted during early autumn or late spring in conditions in which enough moisture is available for rapid root growth.

Mark out the positions of the plants and dig each pit, allowing ample space to accommodate the roots, rootball or container size. This is usually a quarter to half the diameter again of the rootball. Take care not to smear the sides of a pit dug in heavy soil as this will effectively cause it to fill up with water during the wetter months, resulting in root dieback, subsequent shoot dieback and in extreme cases, the death of the whole plant.

Remove protection from the roots and place the tree into the hole. Prune any damaged tissue with a sharp knife or secateurs (hand pruners). Position the plant in the pit with roots well spread. Where trees require staking, the stake should be hammered into the ground before planting the tree to avoid damaging the roots. Position the stake on the side from which the wind most commonly blows.

PLANTING OUT CONTAINER-GROWN PLANTS

Container-grown specimens may be planted throughout the year, provided that the ground is sufficiently moist and adequate water supplies are available and used to irrigate the newly planted area. Other site-related stresses, such as high wind and hot conditions, may also have to be minimized where plants are planted outside of the optimum winter period. Preparation of the planting pit, and staking, are the same as for bare-rooted or rootballed trees, but the positioning of the rootball and treatment of the roots differs slightly. Remove the tree from the container and lightly shake out the rootball over the hole of excavated soil. Check the root collar area for girdling roots. These are roots that spiral around and may eventually damage the developing stem. Where present sever these cleanly with a knife and remove carefully out of the rootball. Tease out the lower roots using a fork. Place the rootball in the hole so that the roots are spread out and the surface of the potting mix is level with the ground. Tease out the circling roots at the edges of the rootball with a fork or by hand especially where plants are pot bound. Fill in and firm, staking where required.

Immediately after planting, remove any damaged, diseased or untidy growth. Do not remove excessive amounts of top growth, however, as this will reduce the plant's ability to produce food.

STAKING TREES AND SHRUBS

Large shrubs and trees larger than about 1.2m (4ft) may require staking. Low stakes are now recommended as they allow the top growth to move in a circular motion. This motion encourages rapid lower-stem thickening and the development of fibrous root systems that are essential for quick establishment and support of the plant.

PROTECTING NEWLY PLANTED SPECIMENS

Plants unused to cold or hot drying winds may suffer from drought stress. Cold drying winds may damage foliage, buds and branch tips, as well as the bark of thin-barked tree species unused to such exposure. Tree shelters protect trees from adverse conditions, providing an extremely suitable environment for the rapid growth and development of the tree. They are also useful in protecting plants from voles, rabbits and sometimes deer attack. They are usually designed to last three to five years before the material starts to degrade under the action of sunlight. Shrub shelters are similar in most respects to those for trees but are generally shorter.

STAKING A STANDARD ROSE



1 *For a standard shrub, make sure you use a strong stake. It should be of a rot-resistant wood. Firmly place the stake in the planting hole, knocking it into the soil so that it cannot move.*



2 *Plant the shrub, pushing the rootball up against the stake, so that the stem and stake are approximately 8–10cm (3–4in) apart.*



3 *Firm the soil down around the plant with the heel of your boot.*



4 *Although you can use string, a proper rose or tree tie provides the best support. Fix the lower one 15cm (6in) above the soil.*



5 *Fix the second tie near to the top of the stake, but just below the head of the standard shrub.*



6 *Water the ground around the plant thoroughly and mulch with chipped bark or a similar material.*

Spiral guards, designed to protect larger trees from rabbits, can act as tree shelters for smaller plants. When used on larger trees, they are designed to expand as the stem diameter increases, thereby not constricting growth. Open-mesh guards, which are mesh rolls supported with two or more canes or stakes, provide alternative rabbit protection.

Re-firm roots of all newly planted trees and shrubs after wind or frost, using the heel of your boot, to exclude air pockets around the roots.

Irrigation should only be applied on very dry soils during the first year of establishment. Water is best applied only when absolutely necessary using a sprinkler to thoroughly drench the soil.

All shrub and tree bases should be kept weed-free during the first year. Mulching may help to achieve this, but some hand weeding may be necessary.

RENOVATING OLDER SHRUBS

Shrubs that become overgrown look unsightly and will often have a poor display of flowers. Many shrubs can, however, be rejuvenated by pruning. In certain cases the pruning programme can be staggered over a period of two or more years. Deciduous species, such as lilacs (*Syringa*), may be pruned after flowering, or more commonly during the dormant season. Evergreen shrubs, such as *Viburnum tinus*, are best treated in mid-spring. Remove all weak spindly growth and any badly placed branches or crossing stems. Remove stems to leave a balanced framework by cutting them back to around 30–45cm (12–18in), depending on the species and its vigour. Mulch using leaf mould or compost to 5–10cm (2–4in) in depth. Ensure that the plant is never short of water in the summer.

The following season the shrub will have produced a mass of new shoots. These should be thinned as necessary. After renovation, all shrubs should be pruned according to their normal requirements.

RENOVATING HEDGES

If hedges become overgrown or too wide through neglect or incorrect maintenance, they may respond to drastic pruning methods. The method is similar to that which is carried out on shrubs. Instead of cutting hard back to the base, however, only one side of the hedge is pruned back hard to the main stems of the hedge plants.



Left: *Flowering trees such as these cherries (*Prunus*) can provide a welcome and refreshing splash of spring-time colour.*

One side of the hedge is left alone so there is enough foliage area left to stimulate new growth and recovery on the pruned side. This can also prove useful in providing cover for wildlife, especially nesting birds.

The process is repeated on the other side of the hedge the following year or, perhaps, two years later. Evergreen subjects (but not conifers) should be pruned in this way during early to mid-spring and deciduous subjects when they are dormant in late winter.

Feed using an organic mulch, such as farmyard manure, and water during the following season to ensure that the hedge survives such drastic pruning. This technique can be very successful for many evergreen plants as well as most deciduous plants.

RENOVATING WOODY CLIMBERS

Climbers that have not been pruned or trained properly often degenerate into a tangled mass of woody stems which look unsightly and give poor foliar or floral displays. Hard pruning will often rejuvenate the plant. In most cases, the plant will tolerate close pruning in early spring to within 30–60cm (12–24in) of the ground or its main framework of branches. Plants in poor health may not survive this treatment, in which case you may need to carry out the work over a period of two or more years.

Water the base of the plant well and apply bulky organic material. New growth must be trained and pruned according to the species. New growth can initially be trained as if it were a newly planted climber.

PROVIDING PROTECTION



1 *Many shrubs need some winter protection. This shrub is in a pot but the same principles can be applied to free-standing shrubs. Insert a number of canes around the plant. Cut a piece of horticultural fleece, hessian (burlap) or bubble plastic to size, allowing room for overlap. Wrap around the plant, using a double layer for very tender plants.*



2 *Tie the protective cover around the pot or lightly around the shrub if it is in the ground. Horticultural fleece can be tied at the top because moisture can penetrate, but, if you are using bubble plastic, then leave it open for ventilation and watering.*

FLOWERS FOR BEDS AND BORDERS

Flowers are an essential part of the ornamental garden and there can be few sights that can rival a flower border at the height of summer. Understanding the lifecycles and horticultural needs of these plants is essential if you are to use them to their best effect in flower beds and borders. This section looks at planting and caring for herbaceous perennials, bulbs and annuals.



Above: *Few sights in the ornamental garden can rival that of a flower border in full bloom in mid-summer.*

HERBACEOUS PLANTS

The strict definition of a herbaceous plant is one that dies down to or near to ground level each year in order to avoid harsh and extreme weather conditions. In the garden this includes herbaceous perennials as well as grasses – which may not actually die down but never exceed a certain height – and bulbs.

Herbaceous perennials are non-woody plants that live for more than one year. They usually grow, flower and set seed before dying down to ground level in the autumn. They remain there until the next season when the cycle begins again. Herbaceous perennials may form sizeable clumps which are best divided every three to five years to maintain vigour and promote flowering.

Ornamental grasses contrast superbly with broad-leaved plants and narrow-leaved forms and are ideally suited for creating "dry" gardens.

The maintenance requirements for the vast majority of these plants are the same and they form the backbone of the ornamental garden by providing colour which, if planned properly, may benefit the garden all year round.

Planting out Herbaceous plants may be planted in either autumn or spring. The advantage of autumn planting is usually noticed on drier soils as the plants establish and are potentially more drought resistant. Those planted on heavier soils may benefit from spring planting, as heavy soils may be wet and cold – conditions that may cause the newly planted specimen to rot. Grasses are planted in the same way as "true" herbaceous plants. Bulb planting is different and is dealt with separately.

Pot-grown specimens should be watered at least an hour before planting. The ground should be dug and manured before being levelled ready for planting. A base dressing of bonemeal or fish, blood and bone may also be applied. Plant only when the soil is moist, but not waterlogged or frozen. Dig a pit larger than the rootball and ensure that the plant is well firmed, taking care not to compact the soil when it is returned around the rootball. Care should be taken immediately after to ensure that slugs and snails do not damage the crowns. Set traps and barriers around them to avoid this.

Thinning Removing weak shoots allows the plant to divert its energy into the remaining shoots, which will be sturdier and produce larger flowers. Thinning is carried out when the plant has reached one-quarter to one third of its eventual height and is useful for plants such as as delphiniums, phlox and Michaelmas daisies.

Stopping This is the removal of the growing tip of a stem in order to encourage the side shoots to develop. The tips may be

HOW TO PLANT PERENNIALS



1 *Always prepare the soil first. Dig it deeply, remove weeds, and incorporate a fertilizer and well-rotted compost if the soil is impoverished. Most perennials are sold in pots, so arrange them to create pleasing associations.*



2 *Water thoroughly at least an hour before knocking the plant from its pot, then dig a hole. If the rootball is congested, tease out a few roots first. Work methodically from the back of the border or from one end.*



3 *Carefully firm the soil around the roots with the heel of your boot. This helps to remove any large pockets of air.*



4 *It is important that you always remember to water thoroughly after planting and keep the new plants well watered in dry weather for the first few months.*

pinched out when the plant has attained a third of its ultimate height. This encourages the buds on the leaf axils to develop and leads to more flowers being produced, although these will be smaller than if the one terminal bud had been allowed to flower. This technique is successful for a range of plants including *Helenium*, *Rudbeckia*, *Dahlia* and *Chrysanthemum*.

Dead-heading Unless the plant produces decorative seed heads or seed is to be collected for propagation purposes, it is often best to remove all flowers as they begin to fade. Further side shoots will then often develop and the flowering period will be extended. Notable exceptions to this are those plants that produce seed heads that are valuable food sources for overwintering birds. Examples of this include teasels, *Echinops* and many of the ornamental grasses.

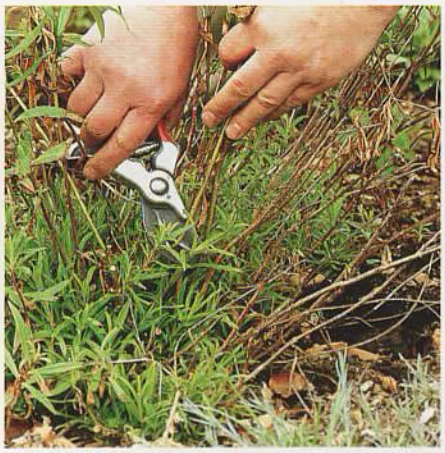
Cutting back Some shrubby perennials (often referred to as sub-shrubs), such as *Chrysanthemum*, *Phygelius* and *Penstemon*, benefit from being pruned annually in early spring. This is especially true of sub-shrubs that are somewhat tender. The older twiggy and unproductive growth is cut hard back in order to promote the growth of new shoots that will flower in summer and autumn.

Feeding Few perennials require more than an annual fertilizer application if initial soil preparation has been thorough and included the addition of bulky organic matter. An organic fertilizer, such as bonemeal or fish, blood and bone, may be added to the soil in spring, preferably after rain.



Above: *When dead-heading, snip off the flowers cleanly where they join the stem. Cut back to the first set of leaves if a whole head of flowers has to be removed.*

CUTTING BACK



1 *Some herbaceous plants remain green throughout winter. Cut back to sound growth, removing dead and leggy material.*



2 *Here, the old stems have been cut off so that they are level with the emerging growth, so as not to damage it.*

Bulky organic material, such as leaf mould or compost, applied in spring before shoot growth is also beneficial. Care must be taken not to apply this too thickly and not to cover the crowns of plants resting at the soil surface as these may rot off.

Renovating Herbaceous perennial plants should be lifted, divided and replanted every three to five years. Some fast-growing and vigorous plants, such as *Ajuga* and *Stachys*, may need to be divided every year. Herbaceous plants can become woody towards the centre and may lose vigour.

Lifting the plants for dividing will not only rejuvenate them but also allows for other border maintenance operations to be carried out. The site can be cleared of any weeds and organic matter such as compost or manure dug into the border. The process of division is beneficial to the whole border. In addition, it keeps the plant healthy and will prevent the over-vigorous growth of fast-growing species. Lifting and dividing is normally done while the plants are dormant in late autumn or early spring.

Transplanting Most perennials can be transplanted relatively easily. This should be done during the dormant season, which is usually in autumn or early spring. Some plants dislike cold wet conditions and these should be moved once the soil has warmed sufficiently to encourage growth. This is particularly true for any plants that are not fully hardy. Some plants that are relatively long-lived, such as peonies, resent being disturbed and will take two or more years to establish again after transplanting.

Plant replacement If possible, all planted areas should be designed to contain plants that have similar life spans and respond to rejuvenation techniques. Some species are relatively short lived and will die out before others within a bed. It is possible to rejuvenate beds on a set cycle, say every three to four years, and avoid gaps appearing in the periods between.

Plant losses can occur in severe winters when those that are normally regarded as hardy are exposed to very low temperatures. Half-hardy or tender perennials are even more susceptible. Some perennials are probably best lifted and stored over winter until the worst weather has passed, when they can be planted out again.



Above: *Lightly dig over the soil around the plants, removing any weeds. Avoid digging around plants such as asters which have shallow roots.*

ANNUALS AND BIENNIALS

As the name suggests, annuals are plants that grow, set seed and die, completing their lifecycle within one growing season. Some garden annuals may actually be perennials in nature, but are treated as annuals for ease of cultivation. Many half-hardy and summer bedding annuals fall into this category. Almost all spend a maximum of one calendar year in the ground before dying off.

Biennials are similar to annuals as they flower once and die, but differ in that they grow and establish in the first season before resting in a similar manner to herbaceous perennials over winter. They grow, flower and die the following season. Some plants that are grown as biennials (especially as bedding) are perennials. They are treated as biennials, however, because they tend to weaken during their second year and are therefore better re-started in order to maintain vigorous plants.

Annuals are used as displays in their own right or as small groupings of colour among more established plantings. Groups of annuals strategically placed together in, for example, containers can have a greater visual impact than if they were spread throughout the garden. Many annuals, especially those with composite flower heads, attract beneficial insect species into the garden and some are used as companion planting for vegetable crops. Annuals can also be a useful infill in new borders as they are easily removed or thinned out later when the perennials have grown and become established.

Planting annuals, biennials and tender perennials Hardy annuals can be sown *in situ* and then thinned. Some may self-seed freely through borders. If annuals are to be grown in pots or trays prior to planting, the planting is much the same as for herbaceous plants. Always ensure that the risk of frost has passed before planting out tender specimens and that these plants are acclimatized thoroughly beforehand.

PLANTING ANNUALS



1 *Remove the plants from the pack. If they are attached to each other, try not to tear off too many roots when removing. Dig a hole wider and slightly deeper than the rootball.*



2 *Fill in the hole around the plant with soil and gently firm down with your hands. Water the plant with a watering can fitted with a fine rose.*

SPLITTING CONGESTED PLANTS



1 *Some perennials need splitting every few years to keep them flourishing. In spring, lift the whole of the clump from the ground.*



2 *Clean the ground thoroughly, removing any weeds, particularly perennial ones that have appeared since the border was last dug.*



3 *Incorporate some well-rotted organic material such as farmyard manure in order to rejuvenate the soil.*



4 *Remove the earth from the plant and divide. Use the new growth around the edge, and discard the woody centre.*



5 *Replant some of the divisions, making certain that the roots are well spread out. Firm them in and then water.*



6 *Keep the plants watered until they have re-established themselves. They will soon fill out the gaps in the border.*

SOWING SEED IN OPEN GROUND



1 *Dig over the ground and break it down into a fine tilth using a rake. Do not work the soil when wet or it will become compacted.*



2 *Using a garden line as a guide, draw out a shallow drill. Use the corner of a hoe, a stick or a trowel.*



3 *If the soil is very dry, water the drill using a watering can and leave to drain. It should not be muddy for sowing.*



4 *Identify the row with a clearly labelled marker. This is important because when the row is backfilled it will be impossible to see where the seed is until it germinates.*



5 *Sow the seed thinly by hand along the length of the drill. Sowing thinly will reduce the amount of thinning that is required at a later stage.*



6 *Rake the soil back over the drill and lightly tamp it down with the back of the rake. When the seedlings emerge, thin them out in order to prevent overcrowding.*

Many hardy annuals thrive in poorer soils, and are undemanding and easy to grow. Dry banks are ideal for a whole range of species including poppies and nasturtiums, both of which flower more abundantly on slightly poorer soils.

The only "pruning" required for annual plants is dead-heading to promote new shoot and flower development, or stopping to promote side shoot development and multiple flower production as opposed to large single flowers.

BULBS, CORMS AND TUBERS

These rest below the surface and are modified buds, stems or roots. They emerge, often for only a short time to grow and flower, before retreating back down underground to escape harsh weather conditions.

Planting and maintenance Bulbs, corms and tubers can be lifted during their dormant period and transported and stored easily. Generally speaking, bulbs are planted in a hole that has been dug to about two to three times their length deep. Bulbs have a base plate, which is where the roots appear. This must always be placed in the hole roots down and should be in contact with the soil in the base of the hole. Placing fine sand in the base will ensure this. The top of the bulb (the neck) should always point upwards. Fill the hole firmly once the bulb is in the hole. After this the bulbs need little care and attention, although tall varieties may need staking and all should be dead-headed after flowering.



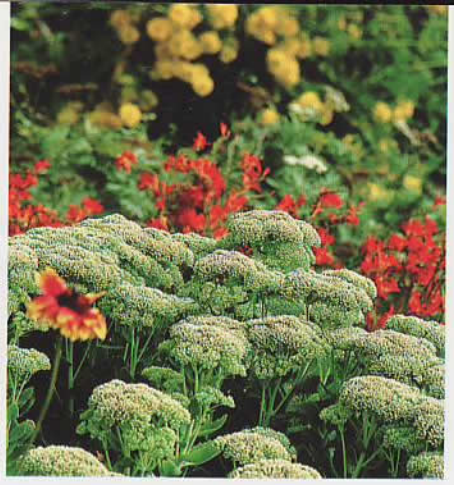
Above: *The rule is that bulbs should be planted at a depth of three times their own size. Exceptions include nerines, crinums and some lilies, which prefer to be planted with the top of the bulb at soil level.*



Above: *Dig a large hole, according to the requirements of the individual bulbs or corms. These gladioli corms are placed, base down and nose up, about 10cm (4in) apart. Gladioli corms need to be lifted in autumn.*

BEDS AND BORDERS

Whether you are creating a flower border from scratch or updating an existing design, there are a number of important factors that you will need to consider before you start planting the scheme. Begin by looking very carefully at the site and its conditions. This initial planning and preparation will help you in your choice of plants. Hardiness and suitability to the soil type, as well as the aspect of the site, are also factors that will determine which plants will thrive.



Above: *Flowers are not only decorative, but will also encourage pollinators and other insects into your garden.*

PLANNING AND SITING

Ideally, the bed or border should be positioned in a sunny site away from the shade of trees or buildings unless you intend to plant a border with shade-loving species. A hedge, wall or fence can provide valuable protection for your plants, and will create a warm microclimate for more tender plants. A sheltered spot will also extend the planting season. These structures may also provide a backdrop for climbers.

When you begin planning the border, ask yourself what you hope to achieve. Borders that are to be viewed from a distance will benefit from larger groupings of each plant type. Larger specimens can also appear very striking from further away. These can be used as character plants and provide a recurring theme through your border.

Borders may have a particular theme. They may be planted with fruiting shrubs, plants to create a "tropical" look or fragrant plants such as philadelphus and lavender for rich summer fragrance. Colour also provides interesting themes. A golden border of yellow flowers in association with plants that have variegated or yellow leaves is striking. Remember that you can leave gaps in the planting for seasonal features



Left: *Herbaceous borders are easy to create and maintain, and can provide year-round interest if they are properly planned.*



Above: *Combining strong colours such as orange and blue can produce striking planting associations.*

such as bedding plants and bulbs. Decide what look you would like to achieve before buying any plants.

SEASONAL CONSIDERATIONS

Ask yourself when you want the border to look its best. Perhaps you would like a bright display of bulbs in spring followed by a colourful selection of annuals and bedding plants in summer. Alternatively, you may want to plan for a bed or border that provides year-round interest, in which case you will need to consider a selection of hardy shrubs or perennials that are appropriate for your garden conditions.

Make a list of all the plants that you would like to include and when they will look their best. Many plants have more than one season. For example, shrubs such as *Viburnum opulus* flower in early summer and have bright red berries in autumn. If you intend to use winter-stem shrubs such as *Cornus alba*, then choose varieties with interesting foliage, such as the golden form 'Aurea'.

COLOUR CONTRASTS

Once you have your list of desired plants, consider their colours. Contrasting colours can look effective. Try plants that have blue, purple or pink flowers, and choose as many examples of these as you can find with bronze foliage. A much brighter combination would call for hot vibrant colours such as yellow, orange and red.

Cottage gardens throw all caution to the wind, including a riot of contrasting and clashing colours to provide unexpected and beautiful combinations of hue and form. Alternatively, you might prefer a monochrome scheme, using flowers of one colour – white or cream, say, offset by a display of green foliage.

FOLIAR AND TEXTURAL EFFECTS

Placing plants with contrasting foliage next to each other can create great interest in a border. This is also true where evergreens are used in conjunction with winter-stem colour. *Cornus sibirica*, for example, has striking red stems in winter and is best shown off against a carpet of weed-suppressing variegated ivy. Textural contrasts can also be striking. For example, the bold leaf forms of plants such as *Rheum* contrast well with the more feathery forms of astilbes and *Aruncus* in summer.

THREE-DIMENSIONAL STRUCTURE

When you plan out a border on paper, it can sometimes be difficult to envisage just how it will look when it is established and growing. In order to get a better idea of the final result, it can be helpful to draw a sketch relief of the border. This should always be done as a projection into the future, based upon the lifespan of the plant. This will be the following year in the case of herbaceous plants but may be five years or more in the case of shrub beds.

PLANTING OUT A PERENNIAL BED



1 *If the bed was dug in the autumn, winter weather should have broken down the soil. In spring, rake over the soil and remove any weeds that have reappeared.*



2 *Although well-rotted organic material should have been added at the time of digging, a sprinkling of bonemeal will ensure the plants get off to a good start.*



3 *Draw a grid on a plan and then mark out a scaled-up version on the bed, using sand or potting mix. Alternatively, use string between canes to mark out the plan.*



4 *Using your planting plan and grid as a guide, lay out the plants, still in their pots, on the ground. Stand back, try to envisage the border as it will be, and make any necessary adjustments.*



5 *Dig a hole and, with the plant still in its pot, check that the depth and width is right. Adjust if necessary. Remove the plant from the pot and place in the planting hole. Fill in the hole with soil and then firm the plant in.*



6 *When the bed is completely planted, water in all the plants. They should be kept watered until they have become established, especially throughout dry periods.*



7 *Go over the border with a fork, or use a rake if there is room. This will loosen any compacted areas, as well as level the soil.*



8 *Cover the soil between the plants with a layer of mulch like composted bark to keep weeds down and preserve moisture.*



9 *Mark each plant with a label. The finished border should need little attention, apart from removing the odd weed.*

PLANTING GROUPS

When designing and planning your border, always remember to set out and plant the herbaceous plants in groups of three, five, seven or nine. In this way, you can create a more natural and informal effect because this approach does not show the rigid lines or geometric shapes that often appear when you plant even numbers of plants.

Larger planting groups than this need not adhere to this number rule because an overall random effect is created by the shape of the drift alone. Larger shrubs, such as *Deutzia* or *Buddleja*, can make stand-alone specimens. Smaller shrubs, such as rosemary or potentillas, may well have greater impact if they are positioned in groups.

CREATING BORDERS WITH HERBACEOUS PLANTS

The popularity of herbaceous plants has meant that they are used in a wide variety of different situations in the garden. However, they are primarily used in the herbaceous border where they can be shown to great effect. Three important categories of this kind of border are usually recognized.

One-sided borders These were extremely popular in Victorian and Edwardian gardens and are the very essence of the English "gardenesque" style. The design usually involves creating a border along one side of a pathway, with the plants arranged in order of ascending height from the path edge. The border is usually positioned in front of a solid backdrop beyond which the eye cannot see.

The backdrop may be living, such as a hedge, or man-made, taking the form of a wall or fence. These beds, while pretty, are often limited by their lack of perspective. The relative proximity of the backdrop often draws attention away from the nearer plants and destroys any illusion of distance. This drawback can be rectified by planting mainly red-flowered plants at one end of the border, gradually changing to blue-flowered plants at the other end. This makes the border seem longer than it actually is. Such schemes are only really effective, however, in borders that are 10m (35ft) or more in length.

Island beds These differ from one-sided borders in that the plants can be viewed from all sides by walking around the whole bed. This kind of planting does not have a backdrop and relies, therefore, on the strategic placement of groups of large plants in the centre of the feature. Island borders allow the onlooker to view the plants from a number of different angles, thus enhancing the interest of the border as a whole.

Mixed borders These designs use many types of plant, including trees, shrubs, herbaceous plants, annuals and bulbs. In a mixed border, one group of plants should complement and enhance the other. For example, the trees provide the shelter and backdrop for the shrubs and flowers in a woodland garden. Rock gardens can also be regarded as mixed borders, with a rich (if diminutive) array of dwarf trees, creeping shrubs and ground-hugging herbaceous plants and bulbs.

ROSE BEDS

A well-tended, healthy and pest-free rose bed has long been, and indeed continues to be, the desire of many gardeners. However, roses can be at risk from pests and diseases. This risk is increased when too many roses are grown in one bed. Most modern cultivars are also too highly bred to resist the range of diseases that can affect them, having been chosen for flower size rather than disease immunity. Choose old-fashioned varieties or modern cultivars that offer resistance to disease.

Most rose pests are common garden pests that are easily controlled by natural predators. The trick with roses is to indulge them with plenty of colourful companion planting, especially daisy-type plants – *Argyranthemum* is ideal – which will encourage those beneficial insects into your garden. It can yield wonderful results and makes the bed even more colourful. Old-fashioned roses need less work in general than modern cultivars and are often more suitable for pollinating insects like bees.

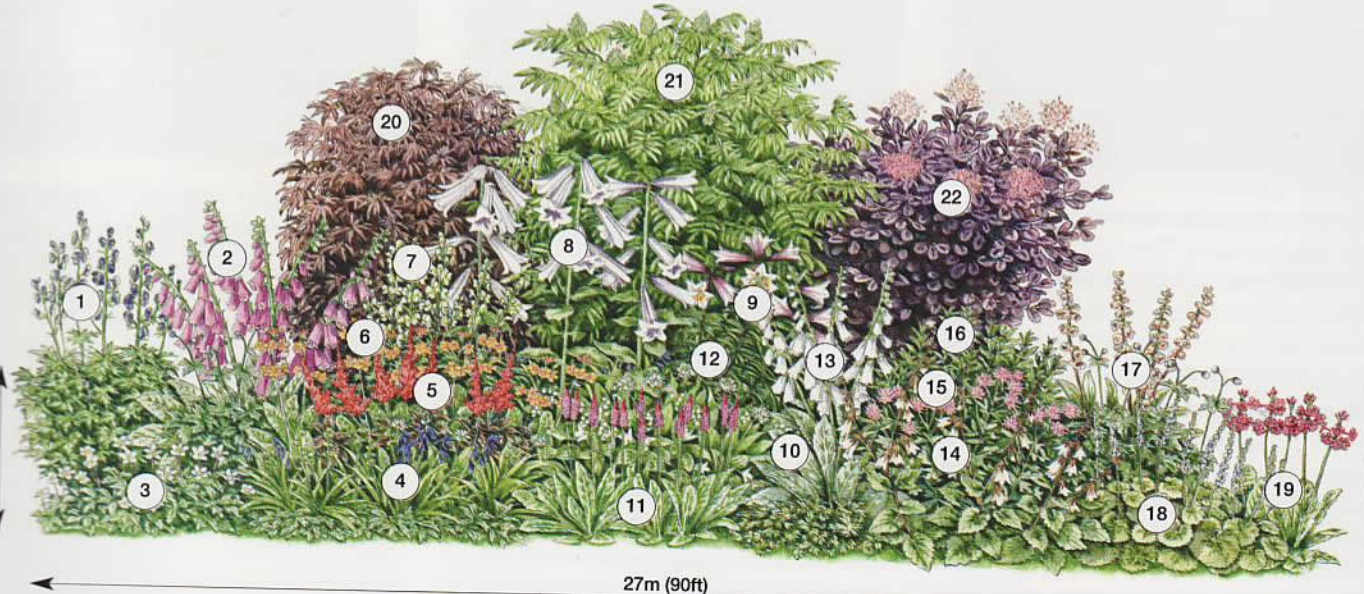
GROUNDCOVER PLANTING

This is a way of exploiting the competitive abilities of plants that grow by spreading sideways and smothering their neighbours. An obvious example of a plant type that is good for this is turf grass, but many herbaceous and shrubby species are also able to fulfil this function. These include conifers, roses, heathers, and both broadleaved evergreens and deciduous

A PARTLY SHADED BORDER

A shady spot in the garden can provide the right growing conditions for a dazzling array of flowers. This mixed border in heavy shade is shown in summer to late autumn.

1 *Aconitum napellus* (poisonous)
2 *Digitalis purpurea* (poisonous)
3 *Anemone sylvestris*
4 *Hyacinthoides non-scripta*
5 *Astilbe* 'Aphrodite'
6 *Primula bulleyana*
7 *Aconitum napellus vulgare* 'Albidum' (poisonous)
8 *Cardiocrinum giganteum*
9 *Lilium regale*
10 *Convallaria majalis*
11 *Primula vialii*
12 *Anemone nemorosa*
13 *Digitalis purpurea* var. *alba* (poisonous)
14 *Campanula alliariifolia*
15 *Aquilegia vulgaris stellata* 'Nora Barlow'
16 *Aster novi-belgii*
17 *Digitalis ferruginea* (poisonous)
18 *Galax urceolata*
19 *Primula japonica* 'Millers' Crimson'
20 *Acer*
21 *Mahonia* 'Charity'
22 *Cotinus coggygria*



plants. Their main characteristic is a close, compact and low-growing form that suppresses the underlying weeds. The same effect can, of course, be achieved by planting closely. This method is especially useful with herbaceous plants that grow up quickly and suppress the weeds below. No groundcover will suppress all weeds, however, and you may have to weed among them while they become established.

There are numerous groundcover roses available that offer a colourful carpet of flowers. If you opt for roses as a groundcover, you should be aware that some are covered with thorns and it can be difficult to weed between them. Mulching the bed following planting can help to suppress weeds until the plants achieve full cover. All groundcover can take two to three years (or more) to become fully established and so should be considered as a long-term, labour-saving feature.

BORDER MAINTENANCE

It is possible to plan a border to be low maintenance, but there is no such thing as a maintenance-free border. Decide how much time you can spend caring for the border and choose your plants accordingly. A close planting, particularly one that uses ground-covering shrubs or closely planted herbaceous plants, will certainly cut down on the weeding as can mulching the border regularly. Any border will need at least one seasonal tidy up in late winter. Shrub beds are also best mulched at this time before bulbs and other flowers have fully emerged. Choose shrubs that will grow into the space available and avoid very vigorous varieties or ones that need pruning on a regular basis. Even large herbaceous borders need not be too difficult to maintain. Delay your winter clear up for as long as possible and choose species that do not need staking. Do not worry if the plants grow among each other, it will just add to the effect. The less labour a border needs, the less disturbance there will be to the wildlife it contains.

TIDYING UP



1 *Some edging plants spread out over the grass, possibly killing it or creating bald patches, as has this poached egg plant (*Limnanthes douglasii*).*

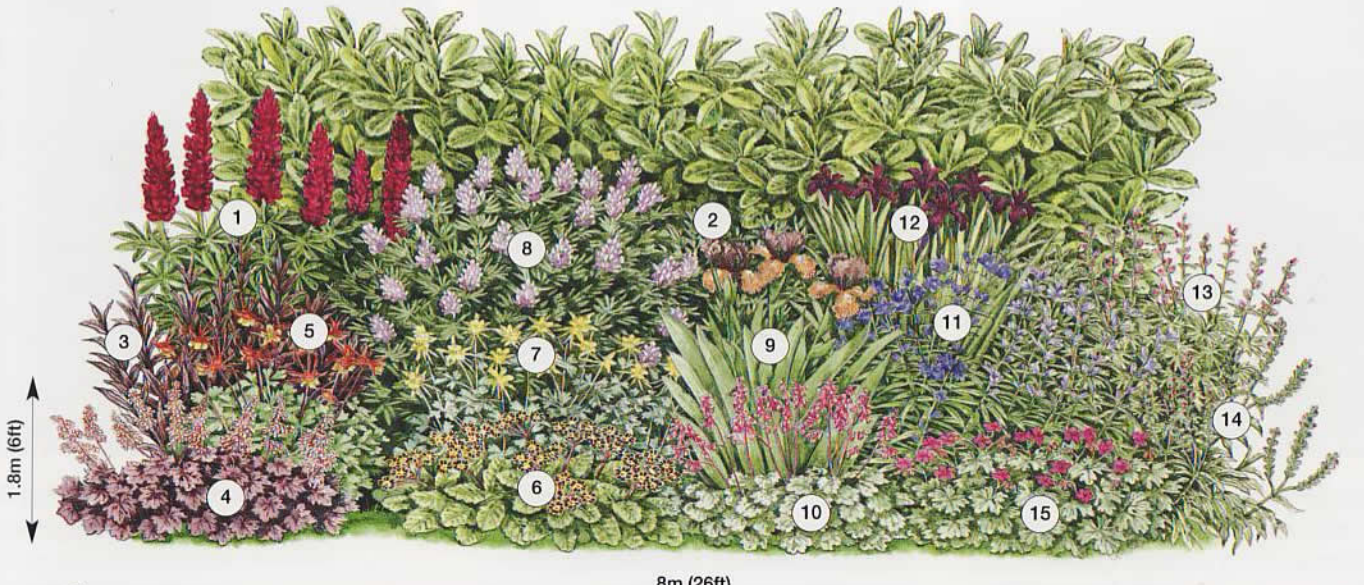


2 *If the plant is an annual and has finished flowering, it can be removed. Otherwise, just cut back the part that is encroaching on the grass.*

A SPRING BORDER FOR AN OPEN, SUNNY SITE

A sunny spot can provide the ideal conditions for a wide range of showy blooms in the early part of the year. The plants in this border prefer a neutral to slightly alkaline soil.

1 *Lupinus* 'The Page'
2 *Aster novi-belgii* 'Fellowship'
3 *Lobelia* 'Bees Flame'
4 *Heuchera micrantha* 'Palace Purple'
5 *Aquilegia skinneri*
6 *Primula* 'Gold Lace'
7 *Aquilegia chrysantha* 'Yellow Queen'
8 *Lupinus arboreus* 'Mauve Queen'
9 *Iris* 'Blue Eyed Brunette'
10 *Heuchera* 'Leuchtkäfer'
11 *Campanula latifolia* 'Brantwood' (deep blue) and *C. latifolia* 'Gloaming' (light blue)
12 *Iris chrysographes*
13 *Sidalcea* 'Party Girl'
14 *Physostegia virginiana* 'Vivid'
15 *Geranium macrorrhizum* 'Ingwersen's Variety'



CONTAINERS

These are an attractive feature in any garden and are very useful when there is no soil at all for planting, as is the case with patios and roof gardens. They are also easy to maintain. There are many types of container available, which means that you can create a theme of your own choice: Mediterranean or perhaps lush and tropical in style. You can also plant up seasonal containers to create different effects through the year or you can change the style from year to year.



Above: *A wooden barrel makes an attractive container in which to grow a profusion of plants.*

TYPES OF CONTAINER

Always choose containers that fit in with the general garden style and with each other. Terracotta and wooden planters are easy to fit into almost any garden scheme, but shiny metal containers may be more difficult to place. Hanging baskets usually take the form of a basket of wire, but they can also be made of wicker. This is lined with a permeable material such as wool, hay, coir matting or even conifer cuttings. You can buy purpose-made lining material which is made from recycled materials or you can make your own. Hanging baskets are an excellent way of covering a wall or post and can even increase the growing space in your greenhouse. They are best planted with a selection of trailing plants (placed around the edge of the basket) and upright types (placed in the centre). They are extremely prone to drying out and should be watered at least once a day and even twice in hot dry conditions. Window boxes should be treated in a similar way to hanging baskets.

The size of a container will influence the kind of plant that you can grow. Any container must be at least 15–20cm (6–8in) deep, although most plants will be happier in a deeper one than this. Be wary of putting a small plant in a very large pot, as this can lead to very wet potting mix that the plant will not want to root into. Large pots with arrangements of several plants are ideal and much easier to look after than several smaller pots.

MATERIALS AND FINISHES

Containers are available in a range of different materials and finishes. Glass fibre and resin containers are extremely strong and lightweight but they tend to be expensive because they are hand-made. They are available as extremely realistic stone-look containers, but can also be found in almost any other finish, including wood and glazed ceramic. Plastic containers are very cheap, lightweight and often last a long time. The finish on some may be poor, but they are very easy to paint and customize. Metal containers are available as pots, "manger-style" window boxes or hanging baskets. There are many different designs and the best quality ones have a properly lacquered finish.

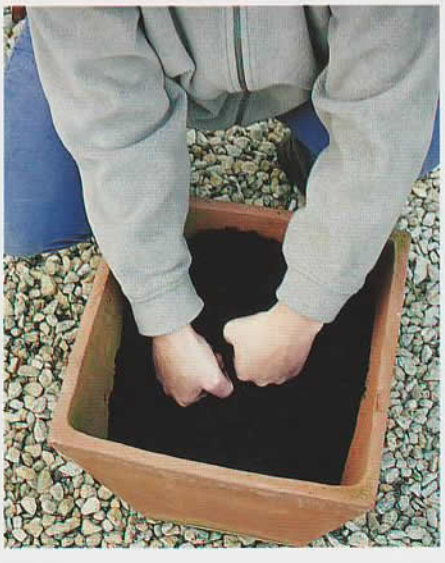
PLANTING A CONTAINER



1 *The materials you need include a suitable container, your choice of plants (in this case, the central plant is a striking cordyline), some stones to place at the bottom of the container for drainage and potting mix.*



2 *Cover the bottom of the container with small stones or some pieces of tile or pottery, so that water can drain freely from the container.*



3 *Partly fill the container with a good-quality potting mix.*



Above: *Hanging baskets can help to provide colour and interest at eye-level throughout the year.*



Above: *Using a watering can is one of the easiest ways to keep the soil moist. It allows you to deliver the right amount of water.*



Above: *You can create a stunning display with a range of different containers, including an old wheelbarrow.*

Stone and terracotta pots offset the shades of flowers and foliage beautifully. The main problem with terracotta is that it is water permeable and requires more frequent watering than plastic, resin or metal pots. Both stone and terracotta containers can be very heavy, so plant them up *in situ*. Look out for frost-resistant types that will not crack in winter. Glazed ceramic pots need less watering than plain terracotta pots, and can be chosen in almost any colour to suit the theme of the garden.

Wooden or wicker planters have a very natural look and can easily be home-made. Oak, cedar and chestnut are the best woods to use because they do not need preservative and planed wood – of any type – can easily be painted. Wicker is an excellent material for making hanging baskets, while wood can be used for window boxes. Wicker or wooden planters benefit from being lined with plastic or a non-permeable paint. The paint can be plastic resin or bitumen based, but make sure that it does not contain fungicides or preservative. Alternatively, plastic sheeting can be stapled firmly inside the pot. Wooden and wicker pots should be raised off the ground slightly to prevent the base rotting. There are many different designs, ranging from half-barrels to wheelbarrows. However, take care with wooden items for outdoor use because many of them have been chemically treated. A wide variety of recycled objects can be used as containers. An old boot, bucket or watering can, painted if you wish, can all be used.

DRAINAGE

All containers must have drainage holes in the base. To ensure that the potting mix drains freely, place a layer of gravel – about 4cm (1½in) deep for most pots – over the base of the pot before putting in the mix. Terracotta and stone pots may need as



4 *Scoop out a hole in the potting mix and insert the plant, positioning it so that the top of the rootball will be level with the surface of the potting mix.*



5 *Place any extra plants around the edge of the main plant. Add more potting mix in order to fill in any gaps, and firm down. Water the container thoroughly.*



6 *The plants will soon grow away and fill out the container to create a stunning year-round feature.*

much as one-fifth of their total depth filled with gravel to help protect them from frost damage. Standing pots on bricks or purpose-made "feet" also helps them to drain freely.

ORGANIC POTTING MIX

The best potting mixes contain sufficient air space to allow the roots to breathe, while retaining enough water and nutrients to support plant growth. Potting mix must also be heavy enough to support the weight of the top growth of the plant if it is to remain upright. You can buy a general-purpose potting mix, although some gardeners prefer to mix their own.

Potting mix can be loam-based or soilless. Loam-based potting mix is a "heavy-weighted" mix that provides good anchorage for tall or heavy specimens. It also holds on well to nutrients. It is ideal for plants that will stay in containers for several years or more as it will not degrade or become structureless.

Soilless potting mixes do not contain loam. They have the advantage of being free-draining and relatively lightweight, although some grit or sand is usually added to give them weight. Coir-based potting mixes are made with a natural fibre that is a by-product of the coconut-growing trade. It has been hailed as a peat substitute and is equally good in containers. However, it is expensive and can be difficult to re-wet once dry. Composted fine bark is cheap and readily available. There have been some advances in its use in recent years and it has even been suggested that bark-based potting mix increases a plant's resistance to pest and disease attack.

PLANTING A HANGING BASKET



1 *Line the hanging basket with a suitable organic material. Conifer branches are an ideal material, as is shown here.*



2 *Fill the lined basket with a suitable soilless organic potting mix to about one-third of its depth.*



3 *Position the plants first to see how they will look. Fill in the spaces between the plants with more potting mix.*



4 *Any gaps between the plants can be filled with small bulbs or bedding in order to provide a riot of spring colour.*

MAKING ORGANIC POTTING MIX

You can make your own potting mix with ingredients such as well-rotted compost, leaf mould and worm compost; loamy garden soil; and clean, coarse sand or fine grit. The organic matter and loam should be thoroughly sieved. A slow-acting, balanced fertilizer may also be added along with ground limestone to bring the mixture's pH to around 6.5 which is suitable for the majority of plants. Containers for seasonal displays such as bedding will not need loam.

PLANTS FOR CONTAINERS

Fruit, herbs and even vegetables can all be grown in containers, as well as a wide range of ornamental plants. A flowering shrub such as an azalea can act as a focal point and enliven a shadier part of the garden. Pots of fresh herbs and salad crops can provide a welcome addition to summer meals and a window box can even be used as a miniature wildlife garden. Seasonal bedding can transform a patio into a riot of colour and be changed regularly to reflect the seasons. Containers also enable you to grow a range of plants that would not otherwise grow in your soil. For example, if your garden soil is alkaline, you can still enjoy the spring and summer delights of acid-loving rhododendrons, blue poppies (*Meconopsis*) and Himalayan primulas.

CARE AND MAINTENANCE

There are a number of tasks that you will need to perform in order to keep your container plants in peak condition.

Watering Knowing when and how much water a plant needs is one of the most important aspects of container gardening. Often a look at the surface of the potting mix may give the impression that it is dry. If you dig down with your finger, however, you quickly discover moist potting mix. If the mix feels wet, then do not water it.

Feeding Container plants need more fertilizer than plants grown in the open garden because frequent watering washes out the nutrients. For the best results, start feeding container plants six to eight weeks after planting. Use a liquid tea, worm liquid or a purchased soluble food such as seaweed extract or liquid manure every two to three weeks. Apply fish emulsion or garden compost once or twice a season to add trace elements to the mix. Do not add more than the recommended rate of any fertilizer as too much can harm plant roots.

PLANTING A WINDOW BOX



1 *Assemble all the necessary materials. These include the window box, crocks, a good organic potting mix and the plants. If the box is light, assemble it on the ground. If not, then assemble it in position.*



2 *Holes in the bottom are essential to allow good drainage. Stop the potting mix from being washed out by placing crocks over these. If very good drainage is needed, then a layer of gravel can also be added.*



3 *Partially fill the box with potting mix, gently tapping the sides to make sure that no air gaps remain. Never over-firm soiless potting mixes as they will become waterlogged and airless, and the plants will suffer.*



4 *Place the plants in position and check these positions before finally planting. Make sure that they are planted in the potting mix at the same depth that they were in their pots or trays. Plant them fairly close for an instant effect.*



5 *A selection of bulbs makes a useful additional display for the window box. The bulbs can be planted in among the main plants and are best planted in groups of three so that they give a fuller display. Water the basket once it is planted.*



6 *Window boxes that are planted for seasonal display will quickly use up all the available nutrients. This is less of a problem with baskets planted for winter interest, such as this, but summer boxes will need regular feeding.*

Monitoring plant health Containers are best placed where they will receive maximum sunlight and good ventilation. During periods of high temperatures and bright sunshine, many containers may benefit from shade during the hottest part of the day. Shelter plants from severe rain, hail and wind storms. Also watch out for and control insect pests.

Pinch pruning When young, the growth of many ornamentals is readily shaped by the pinching out of young shoots. Many specimens treated in this way yield impressive results. This pinching out, or stopping as it is sometimes called, stimulates the development of side shoots and, if carried out regularly, results in dense bushy growth. The selective use of this method of pruning allows for considerable freedom in the shaping of plants.

MAKING ORGANIC POTTING MIX

Mixing your own organic potting mix is relatively easy. You can use a combination of a variety of materials, including loam, leaf mould, garden compost and worm compost.

INGREDIENTS	RATIO BY VOLUME	ADDITIONAL INFORMATION
Loam : Leaf mould : Garden compost	1 : 1 : 1	A basic mix that is well drained, fertile and suited for longer-term plantings.
Leaf mould : Worm compost	3 : 1	Very nutrient rich. Add extra grit for better drainage. Best for short-term pots of vegetables, herbs and flowers.
Loam : Manure : Leaf mould	3 : 1 : 1	A rich mix for heavy feeding plants such as pot-grown tomatoes and peppers.
Leaf mould : Loam	1 : 1	Ideal for long-term plantings such as trees and shrubs. Use acidic loam for lime-haters.
Loam : Leaf mould or Coir	1 : 1	Enrich with 225g (8oz) seaweed meal; 110g (4oz) bonemeal; 85g (3oz) hoof and horn; 55g (2oz) ground limestone per 30 litres (63 pints) base potting mix.

THE WILDLIFE GARDEN

Wildlife gardening involves providing food, shelter and a habitat for creatures as well as relying on native plants that are suited to the climate and soils in the locality. A single plant species may directly and indirectly serve species of insects, invertebrates, fungi, and other organisms, which in turn become a meal for larger wildlife such as birds. In time you will have a functioning ecosystem on your doorstep. In fact, creating a garden of this kind can help break up the "grass desert" responsible for reducing the variety of birds, insects and other wildlife.

Left: *Wildlife gardens use plants, such as this fennel (*Foeniculum vulgare*), for their ability to attract insects.*



Above: *Garden wildlife can be both pretty and, in the case of ladybirds (ladybugs), useful for controlling aphids.*



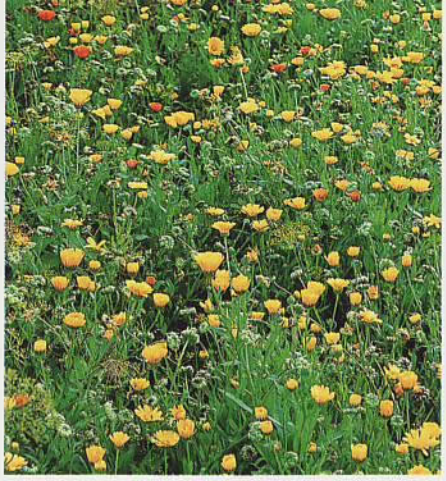
Above: *Flowers such as sweet peas (*Lathyrus odoratus*) encourage pollinators and beneficial insects into your garden.*



Above: *Colourful fruits such as these rosehips provide much-needed food for garden wildlife such as birds.*

WHAT IS A WILDLIFE GARDEN?

The organic garden can provide a welcome refuge for a wide range of wildlife, from birds and butterflies to creatures such as frogs and hedgehogs. The basic requirements for any visitor to the garden are food, water and shelter. You may also want to consider organizing some, or all, of your planting schemes around species that will attract a diversity of fascinating wildlife.



Above: *Wildlife gardens such as this grassland area can be attractive as well as providing useful habitats.*

WHAT ARE THE BENEFITS OF A WILDLIFE GARDEN?

Domestic gardens cover a huge area around our towns, cities and urban fringes. This is a potentially fantastic resource for an otherwise denuded habitat. Keeping your garden free of harmful chemicals gives you a head start in attracting wildlife and, with a little planning, you can create a habitat that will welcome a diverse range of creatures. The visitors in turn will repay you by acting as predators, helping to control the level of problem-causing pests in your garden. Knowing that your patch, no matter what its size, is providing a haven for wildlife will give you a closer connection with the natural world. Just to be able to enjoy watching birds feeding can lift the spirits and improve your sense of wellbeing.

Encouraging natural cycles in your garden will promote biodiversity. The more soil life there is, the more insects will come to feed on it. Birds will come to feed on the insects, as will amphibians and mammals. In this way, food webs will gradually recover in the absence of pesticides.

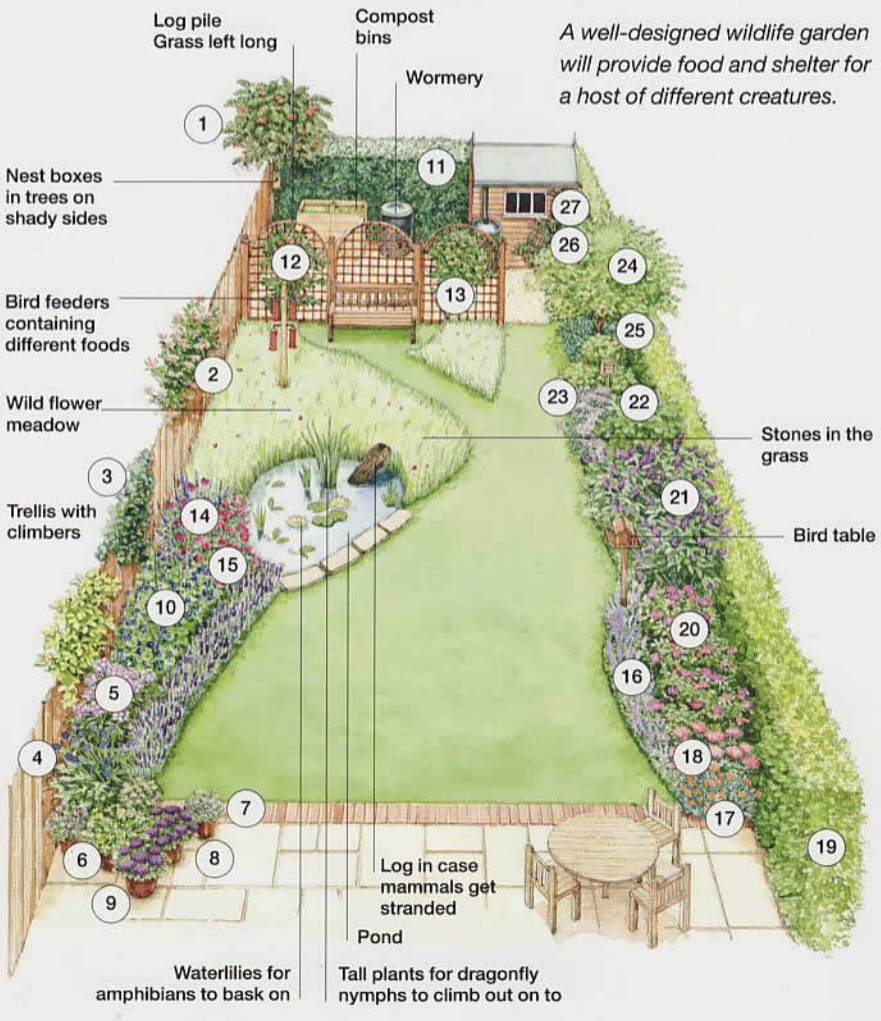
Making your own garden compost, instead of using peat, for instance, prevents damage to a fragile habitat that cannot be re-created. Collecting rainwater and using this in the garden will reduce the consumption of mains water. Huge amounts of energy are wasted on cleaning and transporting this precious resource and it is often extracted from rivers at levels that threaten the local wildlife. The careful gardener can encourage the creation of wildlife habitats in their own backyard and prevent habitat destruction somewhere else.

CREATING THE RIGHT HABITAT

Much of the wildlife that thrives in a garden does so under the care of a gardener who is not unduly tidy. The best wildlife gardens

A WILDLIFE GARDEN

A well-designed wildlife garden will provide food and shelter for a host of different creatures.



1 *Sorbus aucuparia*
2 *Lonicera periclymenum* 'Belgica'
3 *Hedera helix* and *Humulus lupulus* 'Aureus'
4 *Echinops ritro*
5 *Lavandula* hedge
6 *Phlox paniculata*
7 *Nicotiana alata*
8 *Phacelia campanularia*
9 *Heliotropium* in pots
10 *Verbena bonariensis* and *Origanum vulgare*
11 Hedge of *Ilex aquifolium*
12 *Pyracantha*
13 *Clematis tangutica*
14 Mixed planting of *Perovskia* 'Blue Spire' and *Echinacea purpurea*
15 *Centranthus ruber*
16 *Nepeta* 'Six Hills Giant'
17 *Eschscholzia californica*
18 *Sedum spectabile*
19 *Fagus sylvatica* hedge
20 *Buddleja* 'Lochinch'
21 *Syringa* × *prestoniae*
22 *Aster* × *frikartii*
23 *Ribes sanguineum*
24 *Crataegus laevigata* 'Paul's Scarlet'
25 *Mahonia japonica*
26 *Cotoneaster horizontalis*
27 *Jasminum officinale*



Above: *Wildlife thrives in natural wetlands, many of which are threatened by domestic water use.*



Above: *Looking at natural habitats such as woodlands can provide inspiration for your own garden.*

leave room for decay. This approach – and it is one that is good for organic gardens in general – involves piling up old logs and autumn leaves in a quiet shady corner to create a home for insects and hibernating hedgehogs. Do not confuse this with making leaf mould pits; these stay in place and gradually rot down. Log piles can also be overplanted with ivy to enhance both their appearance and attractiveness to insects such as stag beetles.

Consider planting native trees, shrubs and flowers so that native creatures will have a familiar food source or nesting site. Plant as many suitable flowers as possible to attract bees, butterflies and other insects that will enhance your wildlife garden. Many beneficial species are attracted to a garden that is effectively a feeding station for them. For the larger visitors, such as small mammals and birds, you can plant flowering and berrying trees and shrubs.

Ponds provide a rich habitat for a variety of wildlife. Many familiar creatures, such as frogs, toads, newts and dragonflies, depend upon ponds to breed. Many urban gardens have become havens for these creatures. Even a small pool will provide somewhere that birds and other visitors can come to drink. If you have no space for a pond, try introducing a suitable container that can be utilized as a drinking or bathing area for birds, mammals and even insects.

Just leaving the lawn uncut for a few weeks in mid-summer will give many of the plants you do not normally see the opportunity to flower. An area of longer grass also benefits butterflies, moths and many other insect species by providing food and shelter. Many of these insects will fall prey to larger garden occupants such as songbirds and hedgehogs, so diversifying and enhancing the food web in the garden.

The barriers and structures in your garden also provide very useful habitats. Hedges are a sanctuary for all sorts of wildlife, where they can breed, feed and take shelter. These hedges are easy to maintain, as they should only be cut once in the winter to avoid interfering with spring and summer nesting birds. Cutting is done on alternate sides in alternate winters. If one side is cut this winter, then the opposite side is cut the next. This ensures that only one side is clipped before the growing season. The unclipped side flowers and provides nectar and fruit for wildlife. Dry-stone walls are another garden feature that can provide homes for hibernating amphibians, lizards, insects and bees and are best left undisturbed throughout the winter.



Above: *Recycling organic material through composting reduces the need to use substances such as peat.*

If you are lucky enough to have a few trees in your garden, you could try to re-create a woodland habitat. Larger gardens may actually contain a small area of woodland but most are more likely to have a shady patch under a few trees. Choose plants that mimic a woodland floor: bluebells, anemones and sorrel are just a few of the handsome plants that will thrive in these conditions. Planting a few understorey shrubs (those that grow below the trees) such as holly and hazel will complete the effect and may well tempt the shyer woodland birds into your garden.

WILDLIFE CORRIDORS

A wildlife garden is often likened to an oasis in an urban desert. Gardens are the only chance of cover that many creatures have to migrate between larger blocks of suitable habitat such as parks or a greenbelt. If these important habitats become totally isolated then they begin to lose much of their diversity. Town gardens play a vital role in protecting the health of the wider urban habitat, while rural gardens play a similar role in areas denuded by intensive farming. Try putting up a few bird or bat nest boxes and providing nesting areas for insects and mammals. The greater the year-round diversity, the more useful your garden will be.

WOODLAND GARDENS

Woodland can be one of the most interesting and diverse natural habitats. Those with smaller gardens may think that such a feature would be too large for them to create. However, even a few trees in the corner of the garden can provide ample opportunity for the creation of a small wooded area and provide a rich and diverse habitat for a range of visiting wildlife. Try to select native trees or species that have nectar-rich flowers or berries.



Above: *Woodlands are home to many of our favourite garden flowers such as these primroses (*Primula vulgaris*).*

WHAT IS WOODLAND?

Woodland is a very variable habitat and its exact character will mostly depend upon the prevailing climate. It is often a more open environment than that of a forest, having clearings, glades, pools and streams that break up the monotony of tree cover.

Large trees such as oak (*Quercus*), beech (*Fagus*) or plane (*Platanus*) are known as the woodland canopy. Beneath the canopy are smaller trees such as holly (*Ilex*) and hazel (*Corylus*), known as understorey species. They are often shade-tolerant trees, but grow best under gaps in the canopy. Beneath this, a shrubby layer develops in more open woodland, possibly consisting of bushes such as hawthorn (*Crataegus*) and elder (*Sambucus*).

The floor of the woodland is called the herb layer. The plants that live here tend to be seasonal, taking advantage of early spring sunshine to grow and flower, although some, such as mosses and ferns, grow through the summer. It is also where all seedlings grow and is mulched each year with the falling leaves of the trees.

CREATING A WOODED AREA

Gardeners who have a few trees (even if they do not provide a continuous canopy) can easily make a small woodland area. Visit some woods in your area to gain some inspiration and emulate natural growth if possible. Think how the existing tree cover can be linked, maybe by planting more canopy species and some understorey trees.

Woodland environments are often havens for plants and animals, with many containing an enormous diversity of species. This is most pronounced where there is a "mosaic" of open ground and trees. This is because it increases the "marginal areas" – the point between woodland and more open habitat. The places where two habitats meet are always the most diverse. Layered woodland (one with canopy, understorey, scrub and ground herbs) is beneficial for wildlife as it provides ample feeding and shelter for a range of creatures. Any additional planting should always be aimed at achieving or maintaining this layered structure and providing the highest number of habitats.

You can think of woodland as a collection of diverse habitats. Even those that have only a few types of tree are capable of supporting a great number of species that live on or within these trees. Oak trees in Britain, for instance, are known to provide homes for over 400 insect and other invertebrate species. This does not mean, however, that simply planting an oak tree in your organic garden will guarantee all 400 will appear at once. If you aim to create a woodland that is similar to others in your area, then species will be able to migrate from these to the one in your garden.

You may need to provide additional help for wildlife if it is to establish successfully in the woodland area. Nesting boxes, log piles, rocks and a long grass area linked to your pond can all help to encourage wildlife to use your planting as a habitat. Make sure that you include plants that provide food and be prepared to give additional sustenance, especially in the winter for non-hibernating foragers such as blue tits and other woodland birds. As the woodland develops, so will the diversity it contains. Let nature do its work and give a helping hand from time to time.

PLANTING WOODLAND FLOWERS

In most deciduous woodland, the ground is a riot of colour from late winter until early summer as showy woodland species grow, flower and set seed before the leaves in the canopy cast too much shade. As a consequence, most "woodland gardens" are at their best from late winter to early summer. The edges and clearings provide the chance for later colour, of course, but



Left: *Shady and partly shaded wooded areas can provide the perfect habitat for a host of creatures.*



Above: *Foxgloves (*Digitalis*) thrive in shady woodland corners and are very easy to grow from seed.*



Above: *Bluebells (*Hyacinthoides*) naturally grow and flower in the spring before the trees shade them.*

some of the showiest species are to be found among the spring flowers. Choose species that grow in your own area, where possible, because these will be of most benefit to wildlife.

Primroses (*Primula vulgaris*), bluebells (*Hyacinthoides*), snowdrops (*Galanthus*) and wake robin (*Trillium grandiflorum*) are all guaranteed to give a good display, especially at a time when there are fewer colours in the rest of the ornamental garden. Later flowers such as foxgloves (*Digitalis*) should be planted at or near the edge, where they will still get sunlight once the leaves have appeared on the trees. Climbers such as honeysuckle (*Lonicera*) or clematis are also best situated at the woodland edge where you can appreciate the plants as they bloom. It is advisable to always obtain your seed or plants from a reputable source that does the propagation themselves. Never buy bulbs or plants that have been collected from the wild. Your aim is to create a habitat, but not by destroying another.

ASSOCIATED PLANTING

Perhaps the easiest way to mimic a woodland habitat in a smaller garden is to link a few trees with shrubs and understorey trees in order to provide the shelter and food plants that wildlife needs. These shrubs – particularly if they are deciduous – can provide a larger space in which to plant "woodland herb layer" species. Doing this will also widen the edge of the habitat and provide extra coverings around the base of trees. There is, of course, no problem in having a few decorative species in or around your woodland. Try a few rhododendrons, mahonias, lilacs and hydrangeas to provide additional colour and interest if you have enough space. They will all provide shelter and look attractive when they are in flower.

EDGE ENHANCEMENT

Woodland edges are often the most valuable area in many types of woodland for a variety of wildlife and plants. The trick with any wildlife-friendly area is to make sure that these boundaries are as long as possible. Fashioning them into "scalloped" or bay shapes will usually achieve this and each scallop or bay may contain different plants or shrub species. The clearings inside your woodland (if it is large enough) are also important. When you create these clearings, ensure that they are sufficiently long to allow plenty of sunshine into each one. Woodland glades should not be less than 7m (23ft) across and are best if they are irregular in shape.

Remember that the direction of the sun in your garden will affect the type of plants that you can grow at the woodland edge, and butterflies, for example, will prefer a sunny aspect. If the bays or clearings in your woodland area are mainly intended for long grass, then this may only need cutting every two to five years unless, of course, you wish to have a secluded seating area that may need more frequent mowing to maintain access.





Above: Hellebores and Anemone blanda *make an ideal under-planting for trees, providing colour in early spring.*

Left: *Hornbeam (*Carpinus*), grown as a decorative hedge, can be underplanted with a selection of woodland flowers for added interest in the spring.*

WILD FLOWER LAWNS

Compared with a closely mown pristine lawn, an area of rough grass with flowers growing in it can provide a rich haven for a diverse range of wildlife. In nature, many attractive and species-rich habitats develop over time but in the garden, things may need a helping hand. You do not have to let the whole of the turfed area go untouched. Simply leave an area of grass uncut for some of the year and plant it up with your own choice of wild flowers to create a rich habitat.



Above: *Lawns and areas of long grass can easily be transformed into a stunning display of summer flowers.*

PLANTING AND MAINTAINING A WILD FLOWER MEADOW

Small areas of flowery grassland seem to work best when co-ordinated with hedges, shrubs or trees. They are not necessarily spectacular from a distance and need close inspection to appreciate the detailed tapestry of colour and form. Think carefully about where you would like to site such a feature. Always choose a simple mix of species that are well adapted to the conditions in your garden. Take a walk around your home area to see which local or well-adapted species thrive in similar soil types and aspects to your own.

ANNUAL FLOWERS OR PERENNIALS?

Many annuals have attractive flowers and seem ideal for flower-rich lawns but most require yearly soil disturbance and open ground. Poppies and cornflowers are good examples of showy annual plants that benefit from such conditions. Annuals are usually better treated as a separate display. Try planting some wheat or other grain along with the annuals and leave this for foraging birds and mammals. Don't try and harvest the wheat, just cut it down in late autumn and rotavate the plot ready for the spring.

Wild flower meadow species are perennials, which are adapted to life in permanent grassland. The easiest way to make a wild flower lawn is to plant small wild flower plants, directly into an existing lawn. Many wild flowers are easily raised from seed that is available from specialist suppliers. Sowing and growing this is generally the same as for any other herbaceous plant but you should use potting mix that is low in nutrients for the best results. A late autumn or early spring sowing will provide plants that are large enough to plant out in early to mid-summer.

HOW TO SOW WILD FLOWERS



1 *The most satisfactory way to create a wild flower meadow is to sow a special mixture of wild flower seeds. Remember to completely clear the ground of all perennial weeds before you start.*



2 *To bury the seeds, simply rake in one direction and then in the other. It does not matter if some seeds remain on the surface. Keep the area well watered until the seeds germinate. Protect from birds if necessary.*

ADDING INTEREST TO NATIVE GRASSLAND



1 *For a very small area, wild flower plants may be more convenient. You can raise your own from seed or buy them. Plant into bare ground or in an existing lawn.*



2 *Keep the plants well watered until they are established. Several years of successional planting may be needed to fully establish your wild flower lawn.*

Plant these out about 10–20cm (4–8in) apart in groups of 9–15 to ensure that the group can compete with the grass. Mark where you plant them so that you can see which ones have succeeded later.

If your plants do not establish the first time around, then it is worth trying again. Two failures should tell you that they are not suited for your conditions. You can always try a few non-native plants that have proven wildlife value. Prairie plants such as *Echinacea* are very useful in long grass. Try to avoid rare species, as they are likely to be particular in their habitat requirements, and always consider the attractiveness of plants to insects, birds or other wildlife when deciding what to grow.

NATURALIZING BULBS IN GRASS

Bulbs are potentially one of the easiest plants for flowery lawns. Many early-flowering species are suitable, including crocus, iris and snowdrops. Others, such as *Narcissus*, *Puschkinia*, fritillaries and *Leucojum*, provide good displays later in the spring. Planting bulbs is quite simple. Planting holes can be dug singly with a trowel or spade to the required depth – usually two to three times the height of the bulb. Bulbs should be placed with the base plate firmly in the bottom of the hole. An alternative method for large groupings of small bulbs like crocus and snowdrops is to cut an "H" shape in the grass surface and peel the grass back in two "flaps". Place the bulbs underneath with the top uppermost and gently replace the flaps, firming them carefully. Any group of bulbs should be denser at the centre, gradually becoming wider spaced toward the outside, as this will give a natural appearance. Bulbs such as *Narcissus* may survive for many years but some smaller types – crocus being a prime example – may be eaten by rodents.



Above: *Daffodils (*Narcissus*) are an ideal bulb to naturalize in lawns, giving spectacular early-spring interest in the wildlife or ornamental garden.*

HOW TO NATURALIZE BULBS IN A LAWN



1 *Lift an area of turf to create an H-shaped cut. Slice beneath the grass until you can fold back the turf for planting. Loosen the ground, as it will be very compacted. If you want to apply a slow-acting fertilizer, such as bonemeal, work it into the soil at the same time. Scatter the bulbs and plant them where they fall for a natural effect.*



2 *Use a trowel or a bulb planter for large bulbs, making sure that the bulb will be covered with twice its own depth of soil when the grass is returned. Firm down the soil and then return the grass. Firm once again if necessary to make sure that the grass is flat, and water well. Water the grass again in dry weather.*



3 *Special bulb planters can be used for large bulbs. The planters remove a cylindrical core of soil.*



4 *Place the bulb at the bottom of the hole on a bed of gravel to improve drainage, if necessary, and replace the plug of earth.*

CARE AND MAINTENANCE

The time of year that you mow your meadow will influence the species you can grow and also when it will look good. If bulbs are not being grown in the grass then a spring cut can help keep a summer wild flower area tidy, especially after a mild winter. A high cut is best, especially if wild flowers have started to produce leafy growth. Cutting in mid-spring will produce a flowering peak in mid-summer. A slightly later cut in late spring will delay the peak of flowering by a few weeks.

Once flowering has finished, the long grass should be cut down. Spring-flowering meadows are best not cut until after flowering. If bulbs are included then the area should not be cut for six weeks after they have flowered. A second cut in mid-autumn will tidy the area ready for the winter. Summer meadows are usually cut from late summer to mid-autumn. All cuts must stress the grasses but minimize damage to wild flowers. Cuts should be between 30–70mm (1¼–2¾in) in order to achieve this.

Cuttings should be removed to help reduce fertility (as this will help your wild flowers) and to prevent long cuttings smothering the plants below. The cuttings should be left on the ground for three to five days, though, to allow insects to move back into the cut grass below. A portion of lawn may be left completely uncut to protect over-wintering insects, but the portion left must be rotated each year to make sure that the wild flowers survive.

WILDLIFE PONDS

Water is a key element in a wildlife garden. Garden ponds attract an enormous range of living creatures, such as dragonflies, newts and birds, to name just a few of the insects and animals that will visit the garden. Some will come to drink or bathe, others will set up permanent residence there, adding to the beauty and diversity of your garden. A pond not only provides an attractive feature in your garden, but also has far-reaching benefits to wildlife.



Above: *Pond plants are essential to the health and balance of the habitat as well as being highly attractive.*

CREATING A HEALTHY ENVIRONMENT FOR A POND

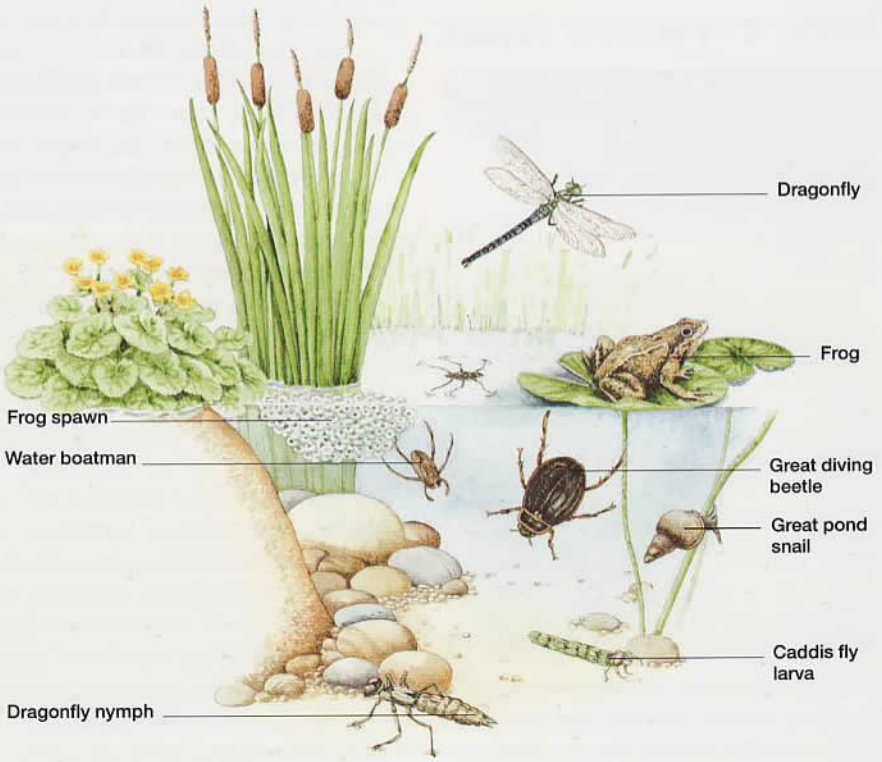
There are a number of points that you must be aware of if you want to provide a safe and healthy environment for wildlife. A pond is always best sited in a sunny position. This is because many pond plants will not prosper in shade, while the water may also be rather cold until the early summer. Shade within the pool is best achieved by surface vegetation, although a pond may have up to a third of the surface in shade if the remainder is well lit. You should also avoid a site near to overhanging trees whose shade can cause the water to be colder for longer in the spring. Falling leaves can cause a build-up of nutrients and increase the potential for toxic tannins in the water. The roots of some species may also interfere with the lining of the pond and can, in extreme cases, cause serious damage.

WATER FOR THE POND

Never fill your pond with tapwater, which often contains many additives, most notably chlorine. Much tapwater can have a high pH and may contain phosphates or nitrates. These can raise the pond's nutrient levels and promote algal growth. Water runoff from nearby lawns or borders can have much the same effect. If the water level becomes very low during the summer it is possible to use solarized mains water to top up your pond. This involves filling large containers with tap water, partially covering the tops and leaving them to stand in the sun for a couple of days. It removes chemicals like chlorine and, although not as good as rainwater, it will stop your pond from drying out. The majority of pool life requires a still environment, so avoid introducing pumps, fountains or filters.

A CROSS-SECTION OF A WILDLIFE POND

Displayed below are some of the more common inhabitants of the garden pool which go towards forming a healthy and balanced ecosystem.



POND SIZE

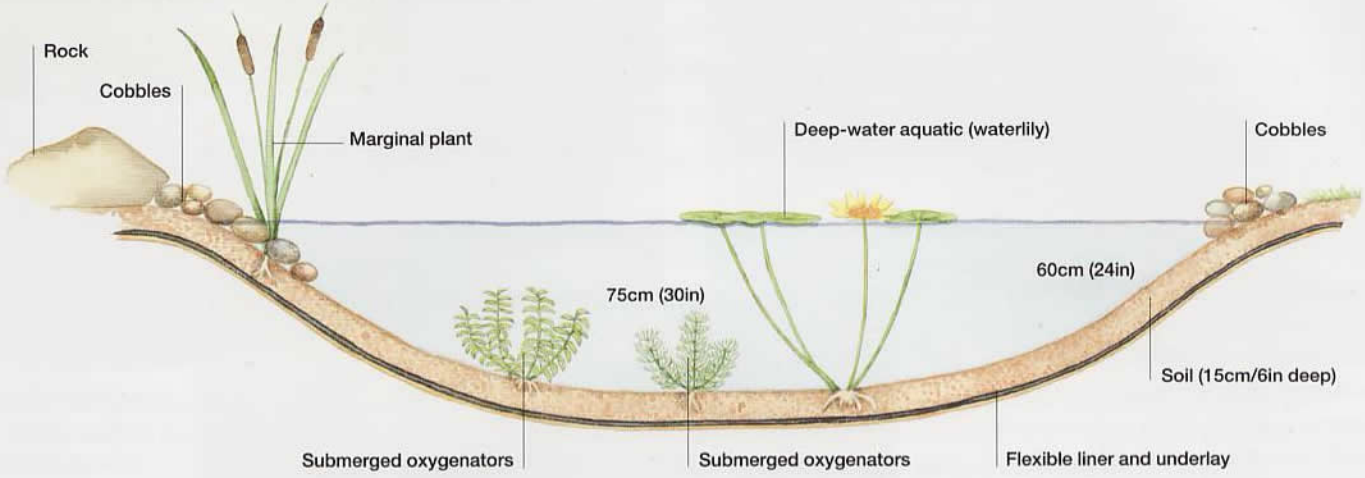
Even small-scale ponds can support an amazing diversity of life. The shallows are the most important areas for wildlife but a depth of at least 60cm (24in) must be reached in some parts to give creatures a place to which they can escape in extreme heat, cold or drought. The greater the surface area of a pool, the deeper it has to be (at its deepest point) to maintain an even temperature throughout the year. The average pool will need to be about 1m (3ft) deep.

STOCKING A POND

Ponds that are designed to attract wildlife should be colonized naturally within a couple of years. This is the best method for stocking your new pond in the first instance as it is providing a breeding place or hibernating area for those creatures already established in your area. Introducing frog (or other amphibian) spawn can sometimes spread diseases such as red leg that can devastate populations of frogs and other amphibians. Never attempt to introduce adult amphibians to your pond. They have an amazingly strong homing instinct and can die in the process of finding their way back.

A WILDLIFE POND

Wildlife ponds depend upon correct planning. Ponds must be both deep enough and possess the right balance of plant types. These plants will provide habitats, shelter, and maintain a balanced environment for the wildlife in the pond.



Avoid introducing fish to small wildlife ponds, as they can exclude other wildlife. Sticklebacks can wipe out the tadpoles of frogs and newts. Fish also eat valuable water-living crustaceans that help to control the growth of water algae and their droppings promote algal bloom.

PLANTING

Bank-side vegetation provides cover for animals entering or leaving the pond. Choose a selection of marginal plants, submerged plants and plants with floating leaves. Leaving long grass around a pond will also provide important cover for wildlife. Gently sloping sides make it easier for creatures to climb in and out of the pond.

Pond dwellers, such as dragonflies and caddis flies, need vegetation to climb out of the water so that the adult may emerge. Small reeds such as the lesser bulrush are ideal but any plants that grow about 40cm (16in) or more above the normal water surface will do.

A log pile nearby will provide a place for hibernating frogs and toads, as well as being a habitat for many other creatures. Add an escape log to help small mammals get out of the pond if they fall in.

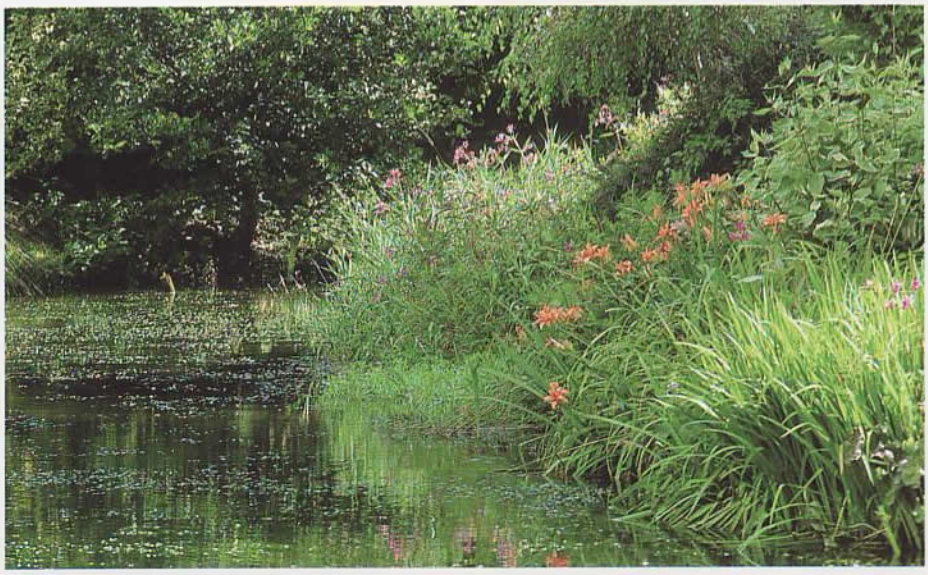
Ideally the water surface should have a third or more covered with plant leaves such as water lilies, water soldier, frog-bit or even duckweed. These help keep the water cool, provide shelter and breeding cover for wildlife and help to prevent the development of algae in the water.

Plants that are to form part of your pond habitat should always be grown in a nutrient-poor potting mix. Slow-release fertilizers effectively act as an algal "time bomb", steadily releasing a supply of nutrients that encourage green water and blanket weed development.

Oxygen is essential for the growth and development of pond-dwelling creatures and can easily be boosted by the inclusion of plants that release it directly into the water. These are plants that are entirely aquatic and do not emerge above the water surface. Plants such as milfoil and Canadian pondweed are often used for this purpose.

Native plants should be a first choice for a pond. Many are showy and often rare or endangered in the wild. If you decide to use natives, never take them from the wild. Always buy them from a reputable nursery or take small offsets from a friend's pond.

Some plants are just too vigorous to be included and will rapidly outgrow their situation. Reedmace (*Typha latifolia*), reeds such as phragmites, floaters such as duckweed (*Lemna*) and the *Azolla* fern are all potentially problematic and should only be included where space permits. They are the equivalent of aquatic weeds and may cause maintenance problems.



Right: *Even a small garden will benefit from a tranquil wildlife pond where animals can come to drink.*

PROVIDING SHELTER

As well as needing water and food, wildlife occupants and passing visitors to the garden need a secure place in which to shelter, where they can feed, nest, breed or escape from predators. Almost every part of the garden can potentially shelter wildlife and the key is not only to provide the right kind of cover but also to make sure that it is not disturbed once it is occupied. These sites can take the form of natural plantings or man-made shelters.



Above: *Providing winter cover such as this lacewing hotel for beneficial insects ensures a healthy population for next season.*

TYPES OF SHELTER

In nature, evergreen trees and shrubs provide year-round cover from weather and predators, while deciduous ones give summer cover for nesting and protection. Dead trees provide habitats for owls, woodpeckers and bats, while fallen logs are host to a wide array of ground dwellers such as wood-boring beetles and other insects.

Centipedes and ground and rove beetles that are active all year round need undisturbed soil, stones and logs. Frogs, toads and newts hibernate through the coldest months, often overwintering in damp hidden sites. Place stones and logs near to a pond and ensure that it has shallow edges and sloping sides. Newts prefer overhanging vegetation to shield them on entering and leaving.

Think about where specific creatures live in nature and aim to mimic these habitats. Sometimes this will involve using the natural landscape or erecting a purpose-built shelter.





Left: *Logs and branches, left over from pruning or tree felling, can be left as a habitat or winter shelter for wildlife.*

LOG PILES

These are an essential part of any wildlife garden because they offer shelter and food for a wide range of different organisms and insects that will in turn provide food for other visiting animals.

Log piles make an excellent place for frogs, toads, lizards, hedgehogs and other wildlife species to shelter, find food, and raise their young. Build a permanent log pile in a shaded area, and let it decay naturally. The logs form food for fungi and insects, while providing shelter for reptiles and small mammals. Dead wood on the ground and especially up in the trees is a very important source of nourishment for insect-feeding birds, such as woodpeckers and tree creepers.

Left: *A shady part of the garden, under the cover of trees, is the ideal place for a log pile. Log piles are both useful for hibernating animals and as a food source for beetles.*

TIDINESS

You should not be in too much of a hurry to clear and tidy up your garden in the autumn, as this will provide shelter during the winter months for a wide variety of garden wildlife. Always be selective, preferably removing only piles of diseased debris. The later you can leave your winter clearance, say until early spring, then the greater the numbers of animals there will be successfully overwintering.

WHICH SPECIES SHOULD YOU SHELTER?

There is a wide range of species that can benefit from cover in your garden. However, you should always try to assess the likelihood that these creatures will actually visit your garden in the first place. There is little point in putting up luxury accommodation for creatures that will never even see it, much less shelter within. The following are some of the creatures that may benefit from a shelter in your garden.



Above: *It is advisable to position shelters for beneficial insects near to a suitable habitat or to a source of food so that they can find them easily.*



Above: *Pollinating insects such as bees need both shelter and protection. Bees are very important inhabitants of a wildlife garden; honeybees pollinate plants in the garden.*

Bats These are probably the most elusive of our garden visitors and because of their nocturnal lives we know very little about them and often, rather unfairly, fear them. Bats roost during the day in tree hollows, in dense shrubs or climbers, and in buildings, although during winter they hibernate, often in deeper, solid places with an even, cool temperature. These fascinating mammals are declining in number due mainly to the loss of roosts and feeding areas, and the increasing use of pesticides. One of the easiest ways to help bats is by putting up bat boxes. These should be located in a sheltered position that gets morning sun and afternoon shade.

Birds The lively activity around your bird table or feeders shows that it can be easy to attract more birds into your garden. Birds need more than just a source of food, though, and suitable nesting sites can be essential for some common garden species. Trees, shrubs and climber-covered walls and fences will provide shelter and nest sites.

Though the term nesting box implies birds may nest in them, only a few species use natural or man-made cavities. Most look for shelter in vegetation, with shrubs being perhaps more valuable than trees for this purpose. You should note that regular close pruning of shrubs might cause growth that is too dense for birds to navigate easily. Try to use native species where possible. Hedges that also produce berries are a good source of food for birds in the colder months.

Butterflies These also require shelter from the elements and a place to roost. The foliage of shrubs is useful as an overnight roost, as are patches of tall grass. You can also provide a place for butterflies to roost, perch, or even hibernate by building a log pile and stacking the logs crosswise to create as many open spaces as possible. The ideal log pile size is about 1.5m (5ft) tall and 2m (6½ft) long. You can also buy a butterfly hibernation house, although there is little evidence that these are ever actually used by butterflies.

Hedgehogs If you lean a sheet of wood at an angle against a wall and stuff it with dry leaves, this will provide a suitable nest for hedgehogs. They will also nest under raised sheds and beneath hedgerows, as long as there are plenty of dry leaves for bedding. You can also provide a winter box in an old compost heap or leaf pile for hibernation.



Above: *You can encourage butterflies into your garden by planting wildlife-friendly plants such as these purple verbenas.*

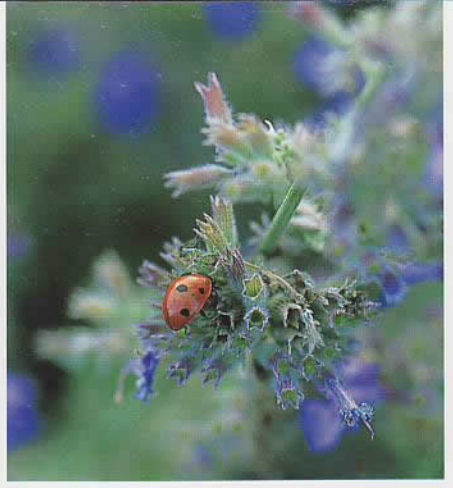
Reptiles and amphibians Rocks, logs, and leaf piles offer cover for small mammals, reptiles, amphibians and insects. In the autumn, try constructing small rock piles that can provide lizards, reptiles and amphibians with a warm winter retreat. If you have a pond, leave brushwood and leaves or rock piles near the bank to provide shelter for amphibians as many of these hibernate in damp areas on the land.

Pollinators Bumble-bees can overwinter in a small terracotta pot filled with moss or finely shredded newspaper. Bury the filled pot upside down and protect the hole from rain with stones, but leave a tiny gap for the bee to get in and out. Masonry bees can be encouraged to take up residence by tying a bundle of bamboo canes together – lengths of about 25cm (10in) are ideal – and then placing them inside a length of old plastic pipe that is about 5–7.5cm (2–3in) longer than the canes. They will make nests inside the hollow bamboo canes and lay eggs within these that will hatch out the following spring. Always place the pipe in a sunny sheltered position where rain will not reach it. You can also buy purpose-built masonry bee shelters.

Predators Lacewings will shelter in a similar construction to that used for masonry bees. Ready-made lacewing hotels are available and are impregnated with a pheromone that attracts the adults in the autumn. Ladybird (ladybug) shelters are also marketed commercially for the same purpose. You can also buy the pheromone with which to impregnate your own home-made shelters.

PLANTS TO ATTRACT WILDLIFE

Plants are the single most important factor when it comes to attracting wildlife into your garden. They provide a food source and shelter for visiting bees, butterflies, moths and a whole host of beneficial insects. Even if your garden is tiny, you can still introduce a selection of useful plants by planting tubs of brightly coloured and nectar-rich summer flowers and pots of sweet-smelling herbs such as lavender and rosemary.



Above: *Beneficial predators such as ladybirds (ladybugs) will be attracted to the garden if you include the right species of plant.*

PLANTS FOR FOOD AND SHELTER

Planting colourful, nectar-rich plants attracts butterflies and other beneficial insects. Choose plants that will provide the visitors with nectar from early spring to late autumn. This of course has the added benefit that your flower beds will be brimming with colour for most of the year. Combine selected species of herbs, wild flowers and cottage garden plants in a herbaceous border to create a butterfly or bee border.

To encourage breeding insects, allow a few nettles and grasses to grow in a secluded corner of the garden or let ivy trail up your fence. These will provide sites for female butterflies to lay eggs and a food source for caterpillars.

Wild or single-flowering varieties of plants are often best for wildlife. You should not be too eager to dead-head plants in autumn.



Many birds feed on spent flower heads such as those of forget-me-nots and pansies. Leave perennial flower stems in autumn, as birds will be attracted to them, searching for seeds and hiding insects. Nesting birds need insects to raise young, so try early-flowering plants such as aubrietia that attract aphids and provide a source of food.

Left: *Plants with composite flower-heads, such as thistles and daisies, readily attract insects to the garden.*

A hedge that is left relatively undisturbed by the gardener can prove a rich habitat for a diverse range of wildlife. Dense hedges give birds protection from predators and provide windbreaks. The thick undergrowth encourages many species of small bird to take shelter and unclipped hedges of all types have more chance of bearing flowers and fruit.

If your garden is large enough to have at least one large tree then this will provide perches and nesting sites for many birds. Native trees are valuable to insects, birds and other animals as they provide better shelter and food than introduced species. The best trees are those that produce



Above: *Choose plants such as roses that have berries or edible fruits for birds and mammals to feed on.*



Above: *Sunflowers (*Helianthus annuus*) provide food for insect pollinators as well as late seeds for overwintering birds.*



Above: *Scabious (*Astrantia*) can be used in flower borders or in wild flower lawns in order to attract insects such as bees.*

seeds or fruit, as these are often a valuable source of food for many birds in autumn or winter.

Shrubs provide shelter for birds, enabling them to nest safely. Choose shrubs such as *Pyracantha*, *Cotoneaster* and *Viburnum* that produce a good crop of berries for the birds to feed on. Climbers are attractive to birds, especially if they are late flowering or bear fruit and seeds for winter food.

Annual species, planted on vacant patches where quick reliable displays of colour are required, will produce an outstanding array of colour, and their nectar and seeds provide valuable food for many types of insect.

Meadow-plant species will provide colour while the foliage of naturalized bulbs withers down. A fine early display can be created under deciduous trees before the soil becomes too dry and shaded, and grassy banks provide a marvellous opportunity for creating a mini meadow. An informal lawn is the intermediate step between a formal lawn and a meadow and is often created adjacent to a formal lawn and sown at the same time. It contains species tolerant of close cutting and if mowing is relaxed in summer, an enchanting display of flowers can be enjoyed for many weeks. When mowing is recommenced no harm will come to the plants, and the practice can be repeated annually.



Above: *Encouraging beneficial insects into your garden by including insect-friendly plants can help to create a natural balance.*

Shaded areas of the garden often present a problem for gardeners, but there are many varieties of woodland plants – often including some of the most beautiful wild flowers such as anemones and foxgloves (*Digitalis*) – that will thrive in these conditions. A woodland area planted with native trees and shrubs is the ideal backdrop for bulbs and woodland wild flowers. This habitat provides a continual source of interest throughout the year and attracts insects, birds and mammals.

Plants growing along and in hedgerows are particularly useful to attract wildlife, especially if the hedge is made up of native species. Plants for sun, shade or semi-shade should be selected depending on the aspect of the hedgerow. New hedgerows should be allowed to establish free of competition for two to three years before associated plants are introduced. Hedges provide corridors for wildlife and sources of interest throughout the year, with attractive foliage in spring, flowers in summer and berries, hips or leaf colour in autumn and winter.

Plants that grow in or around ponds act as a magnet to surrounding wildlife. Damp soil borders and marshy areas are the ideal habitat for many species of wild flower.

Dry-stone walls can also be exploited by planting up nooks and crannies with wild flowers adapted to the conditions, adding interesting foliage and colour.

Combinations of wild flowers can also make excellent subjects for patio tubs, pots and hanging baskets, as many of them are tolerant of drought and have a spreading habit, making them ideal for low-maintenance containers.



Left: *As its common name of butterfly bush suggests, buddleia is a particularly excellent source of nectar for butterflies.*

TOP 20 GARDEN PLANTS TO ATTRACT WILDLIFE

There are literally thousands of plants that all have the potential to attract various forms of wildlife to the garden. Some plants, however, are more effective at this than others. Twenty of the best plants for attracting wildlife that are easy to grow are listed below.

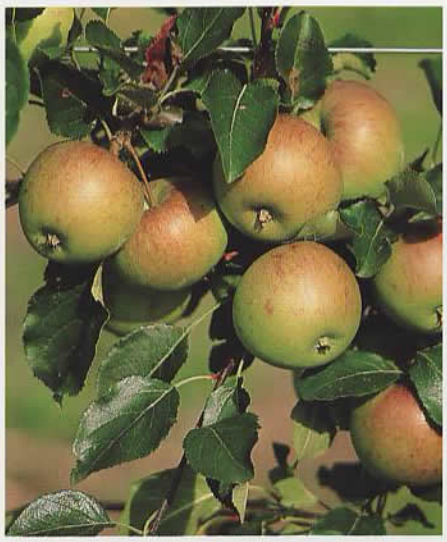
PLANT		WILDLIFE ATTRACTED	BENEFITS TO THE GARDEN
Achillea millefolium **(Yarrow)** A vigorous herbaceous perennial that grows to a height of 60cm (2ft). Flower colour ranges from white through to reds and oranges.		An abundance of hoverflies can be found nectaring on the flowers in summer. Also attracts bees and bumble-bees.	Hoverfly larvae are an excellent addition to the garden, providing efficient control of aphids. The larvae can eat vast amounts of aphids during this part of the life-cycle.
Angelica archangelica **(Angelica)** A tall, upright, herbaceous perennial, more often grown as a biennial, which grows to 1.8m (6ft). The architectural flower-heads bloom in early to mid-summer.		Bees, butterflies, hoverflies, insects and birds all congregate around the huge flower heads of this garden bloom.	This plant can be likened to a supermarket where many species gather to stock up on food. Count the number of species on one bloom, it is amazing.
Aster novi-belgii **(Michaelmas daisy)** The flowers of this herbaceous perennial provide a rich source of late nectar. A full range of sizes and colours are available.		In late summer and autumn butterflies and bees visit the flowers. Birds eat the seed after ripening.	This plant provides a valuable late source of nectar. Butterflies will use this food to strengthen them up for winter hibernation or to produce eggs to overwinter.
Aurinia saxatilis **(Golden alyssum)** Also known as *Alyssum saxatile*, this herbaceous perennial forms a carpet of yellow flowers in spring.		Butterflies, bees and early flying hoverflies are attracted to the bright yellow flowers of this popular rock garden plant.	A very useful source of nectar for all early insects, especially early season or overwintering butterflies.
Buddleja davidii **(Butterfly bush)** This deciduous shrub is often quoted as the saviour of the British butterfly population due to the high quantities of nectar it produces.		As the name suggests, this is an excellent plant for attracting butterflies. Also useful for a variety of nectar feeders, including bees and moths.	Like asters, this is an excellent feeding stop for migratory and resident butterflies. The caterpillars are a good source of protein for birds.
Centranthus ruber **(Red valerian)** A herbaceous perennial that grows to 60cm (2ft). It performs well in poor dry soils and does especially well in seaside locations.		One of the best flowers for butterflies, providing nectar for small tortoiseshells, peacocks, red admirals and white and yellow butterflies.	Butterflies are a good indicator of the health of the environment. Their caterpillars are a good source of protein for nesting songbirds.
Cerinthe major **'Purpurascens'** A small herbaceous perennial that flowers in spring. Produces fantastic blue flowers with lilac bracts. It self-seeds freely.		Bees love the blue flowers and congregate in vast numbers while the plant is in flower.	This early flowering perennial gives a boost of nectar to resident bee populations, which are good pollinators.
Eryngium giganteum **(Miss Willmott's ghost)** A short-lived herbaceous perennial that reaches a height of 90cm (3ft) and has beautiful steel-blue flowers.		This plant hums with bees and bumble-bees during its long summer-flowering period.	An outstandingly beautiful plant that attracts bees which will pollinate your plants. Good for naturalizing in wild areas.
Eschscholzia californica **(Californian poppy)** An annual that produces striking orange, cream, red or yellow flowers which will bloom all summer. This is a small plant, reaching 45cm (18in) in height.		Hoverflies, bees and bumble-bees are attracted to this plant. Once it is sown, it will self-seed freely round the garden.	The bright orange flowers attract hoverflies, the larvae of which are extremely voracious predators of aphids.
Eupatorium cannabinum A tall plant that produces large heads of fluffy pink flowers in late summer. This herbaceous perennial is a must for the wildlife garden.		Attracts butterflies and bees. As well as looking fantastic, this plant is one of the best for providing nectar to adult butterflies.	From mid-summer onwards, this decorative plant offers a rich and steady source of nectar and is a firm favourite with visiting butterflies.

PLANT		WILDLIFE ATTRACTED	BENEFITS TO THE GARDEN
Helianthus annuus **(Sunflower)** If you want to make a statement, grow a few of these in your garden. They have enormous yellow, red or orange heads with some tall varieties easily reaching 2m (6½ft).		Birds such as greenfinches and bullfinches will eat the seeds. Also visited by honeybees and bumble-bees when in flower.	The seeds provide a late-summer boost to the diet of birds and some small mammal species. Good for encouraging birds into your garden.
Humulus lupulus **'Aureus' (Golden hop)** A vigorous climber with twining stems. It is unusual in that it dies down every year. The female plants produce hops that are used in flavouring beer.		Caterpillars of the beautiful comma butterfly and button snout moth feed on the golden foliage.	Food plants for caterpillars and larvae are an invaluable part of a wildlife garden, otherwise we would not be graced with the adult butterflies.
Lavandula angustifolia **(Lavender)** A compact bushy shrub that sports many varieties to choose from. It produces fragrant pink to purple flowers in early summer.		The fragrant blooms attract many different species of bees, bumble-bees and also white and blue butterflies.	Insect-eating birds are attracted to feast on the insects drawn to nectar on these fragrant bushes.
Lonicera periclymenum **(Honeysuckle)** A climber with twining stems reaching up to 6m (18ft). It bears sweetly scented, pink and cream flowers in early summer, with red berries appearing later.		Nectar provides food for bumble-bees, bee hawk moths as well as elephant, lime and privet hawk moths. Fruit-eating birds will feast on the berries.	A superb plant for night-flying moths that should be placed next to the house so you can enjoy both the fragrance and watch these night-flying beauties. The moths are also a good source of protein for birds and bats.
Nymphaea alba **(Waterlily)** An aquatic plant that has large round floating leaves with beautiful white flowers in the summer months.		Adult frogs and dragonflies use the floating leaves of this aquatic plant for basking on. The leaves also provide cover for tadpoles of newts and frogs.	Adult frogs eat slugs and snails. The tadpoles help to control algae in the pond, as it is part of their diet.
Phlox paniculata The lovely, sweetly scented flower heads provide a colourful display in late summer. This 90cm (3ft) herbaceous perennial prefers a moist soil in light shade.		This plant will attract adult butterflies and moths, which will appreciate the nectar from the flower heads in late summer to early autumn.	The moths nectaring on this plant will provide a tasty meal for wandering bats. Butterflies flying during the day will provide a meal for hungry birds.
Rosmarinus officinalis **(Rosemary)** A dense bushy shrub with aromatic foliage growing up to 1.5m (5ft) tall. It bears purple to blue flowers in mid-spring to early summer.		Almost unrivalled in its ability to attract honeybees, butterflies and hoverflies to its nectar-rich flowers.	Honeybees pollinate many garden plants and trees. They are welcomed by farmers into fruit orchards.
Sedum spectabile **(Ice plant)** This small herbaceous plant is one of the best butterfly plants. It has thick succulent leaves and stems that are well suited to growing in hot well-drained positions.		An old favourite for the herbaceous border, Sedum is extremely useful to butterflies, bees and hoverflies as a late summer source of nectar.	Provides a good source of nectar late in the season that is a positive benefit for overwintering butterfly species to build up their energy.
Sorbus aucuparia **(Mountain ash)** A wonderful tree for the small garden. It has attractive white flowers in the spring and bears red fruit in the autumn. It can reach heights of 12m (36ft).		The flowers are excellent for feeding bees and other insects in the spring whereas the berries are consumed by many species of birds.	The tree can attract up to 30 different species of insect, not including the birds and small mammals it feeds, providing a meal for many.
Verbena bonariensis **(Tall verbena)** This versatile plant can be grown as an annual or short-lived perennial, reaching up to 1.8m (6ft). The purple-flowering spikes bloom in late summer until the first frosts.		This is a fantastic plant for nectaring butterflies such as the small tortoiseshell, peacock, red admiral and comma. It is perhaps more effective than the more well-known buddleia.	Good for planting in large groups throughout the garden to attract large numbers of butterflies and bees to pollinate plants and to provide food for garden birds.

THE KITCHEN GARDEN

The kitchen garden is a paradise for gardener and cook alike. Few pleasures in life can compare with the satisfaction of harvesting and eating fresh produce from your own garden. There are many design possibilities when planning a kitchen garden. Some gardeners prefer to lay out their vegetable plot in neat rows; others choose an edible landscape that is ornamental as well as functional. There is also a seemingly endless choice of varieties in seed and nursery catalogues which can be confusing, but merely reflects the popularity of home-growing.

Left: *Kitchen gardens can provide a summer spectacle as well as a wealth of fresh, home-grown food for your table.*



Above: *Fruit such as pears and apples is one of the most welcome delights of autumn in the kitchen garden.*



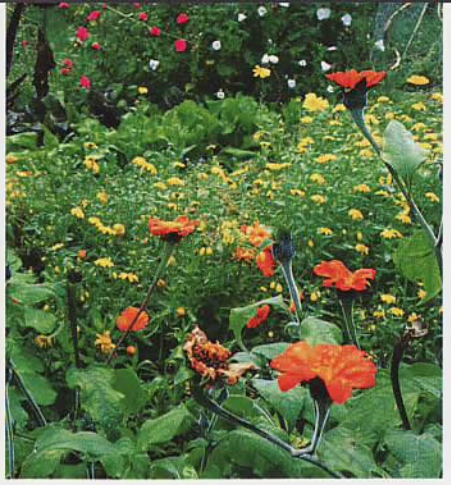
Above: *Companion planting helps to keep plants healthy and also looks attractive throughout the summer.*



Above: *Kitchen-garden plants can be just as decorative as those grown for their ornamental qualities.*

PLANNING A KITCHEN GARDEN

Growing your own vegetables, herbs and fruit ensures that the food you eat is fresh, tasty and chemical-free. The healthiest food is found closest to its source, so freshly picked produce from your garden is both tastier and better for you than that which has travelled long distances by air, sea or road. Your garden will also be more appealing when it is planted with a wide selection of plants that will attract an equally diverse range of wildlife.



Above: *A well-planned kitchen garden, with companion planting, can be a feast for the eyes as well as the table.*

WHAT DO YOU WANT FROM YOUR KITCHEN GARDEN?

An ideal starting point is to make a list of all the vegetables and fruit that you eat on a regular basis, adding in a few that you are curious about and would like to try. The next stage is to look at the size of your garden and consider if there is enough room to grow everything that is on your list. Think about the quantity needed to feed your family. There is no point in planting ten apple trees for a family of four. It is a good idea to start with a few easy crops to build your confidence and progress from there.



Left: *Peas and beans can easily be trained up supports, giving height and structure to the kitchen garden.*

Many edible plants, especially vegetables and herbs, are easy to grow and can be ready for harvesting in a short space of time. Children love to sow and grow less difficult crops, such as spring onions (scallions), radishes, carrots and lettuce. Growing fruit is usually a longer-term investment, as many types, such as apples, pears and blackcurrants, for example, will take several years to crop. Once they start to produce fruit, however, your investment will pay off, as they will continue to crop for many years to come and are less time-consuming than vegetables.

Furthermore, you do not need acres of space to enjoy growing your own fresh fruit and vegetables. In fact, even a small garden will support an edible crop or two. You could grow potatoes in barrels, herbs in pots and fruit trees in ornamental containers. If you live in an apartment, you can use window boxes and containers to grow fresh herbs and vegetables. Try planting hanging baskets with trailing tomatoes, herbs or fruits such as strawberries to overcome space difficulties. Edible gardening involves using any space that is conveniently available. It also promises a colourful garden and unusual ways to feed your family.

DESIGNING THE GARDEN

There are a number of points that you will need to consider in order to get the most out of your kitchen garden and to ensure that the food you produce is safe and fresh. Siting your crops next to a busy road, for instance, can mean eating produce that is polluted by cars. When siting the crops, think carefully about your own garden environment. Each garden is different and has specific requirements for growing various crops. Check the pH of your soil before getting underway as vegetables such as cauliflowers and cabbages will not grow well if the soil is too acidic (under pH of 6.5). As well as testing the pH level, test the soil for nutrients. The results will indicate if there is any need to improve the soil before planting.

The aspect of your garden is also critical in the siting of your plants. Fruit, for example, needs plenty of sun exposure in order to ripen properly and develop flavour. Fruit trees are also often best sited over a lawn to facilitate fruit collection.

Any design needs to consider the difference between annual and perennial crops. Annual vegetable crops, such as potatoes, carrots, cabbages and beetroot, need to be rotated within the vegetable garden to deter soil-borne pests and diseases from attacking them. Strawberries are a good example here, as they are effectively an annual, needing to be divided every year. A strawberry bed that you rotate with flowers and annual herbs (such as basil or dill) is useful for avoiding soil-borne pest problems.

Perennial crops, such as asparagus and rhubarb, may well merit their own distinct areas and are not rotated like annual crops. Raspberries and blackberries, which are both perennial, are best sited permanently on a wire trellis. Avoid putting them in a huge expanding clump that can take over your garden.

Consider, too, how difficult a particular plant (or the produce it offers) is to grow. Peaches, for example, can be challenging. They are disease-prone and require lots of care and attention. Unless you are a committed gardener with time on your hands, it may be best to purchase a few organically grown fruits from a local shop.

PLANTING THE KITCHEN GARDEN

If you have recently moved into a new home, then you will have the luxury of starting your kitchen garden from scratch. If your garden is already established, there is no need to uproot everything to grow your own produce. Gardens need not be exclusively made up of just edible or ornamental plants. You may wish to start by planting a few annual vegetables and herbs among your ornamental plants. Indeed, you can easily incorporate edible plants into the garden, even mixing fruit, vegetables and herbs in ornamental beds. This planting arrangement avoids crops grown in visually uninspiring mono-cropped rows.

If you are planting vegetables in new beds, then they can be interplanted with ornamentals and herbs. Fragrant plants such as English marigolds (*Calendula*), French marigolds (*Tagetes patula*) and oregano (*Origanum*) are excellent choices for attracting beneficial insects, and interplanting with plants such as these will help to keep pests to a minimum. Large blocks of the same vegetable are likely to attract high concentrations of pests, whereas interplanting tends to confuse and dissuade them.

If you need to remove an ornamental tree or shrub that has died or outgrown its site, consider replacing it with a fruit-bearing tree or shrub. There are many possibilities, including apples, currants, raspberries, crab apples, plums and cherries, which can all provide valuable colour and texture in the garden as well as a source of food. Apart from feeding the household, excess fruit from these trees will also provide food for a range of birds and insects.

It is worthwhile researching the eventual height of plants in the planning stages. Some will simply look out of place if they are grown in the wrong location, such as planting tall plants in front of smaller ones. Many large ones will also need some form of staking or support.

Lettuce, chives, pansies and parsley create excellent borders along the edges of raised beds. Tall plants such as dill, sunflowers, daylilies, fennel, valerian, peas and beans are best grown at the back of beds or at the centres of containers. Provide trellises and other supports where needed. Choose edible flowers such as nasturtiums and chives wherever possible because they are a natural addition to gardens and make salad bowls look and taste wonderful.

You may wish to consider an edible lawn, in which some (or even all) of the lawn is given over to a groundcover such as strawberries. Strawberries are a very attractive crop because they produce fruit for most of the summer and tolerate marginal soils and light shade. However, large patches are likely to attract pests, so they should be interplanted with strong-smelling herbs like thyme and oregano which also form good groundcover. It may be an idea to keep a permanent cover of herbs and rotate the strawberry crop on a two- or three-year cycle.

PLANTS USED AS FENCES, SCREENS AND BARRIERS

Plants can be used in a number of imaginative ways. Instead of erecting plain wooden fencing or mesh barriers why not consider planting a living one?



Above: *Onions, with their tall stems, can be grown for their decorative appearance in ornamental beds and borders.*

Gooseberries, raspberries or currants are readily trained along a fence and apples can be trained as an espalier cordon or fan along a wall. Climbing plants, such as hardy kiwi fruits, trailing nasturtiums, broad beans, or sugar snap peas, can all be grown over a fence or trellis work to provide an ornate screen. Hedges can also form useful and attractive edible barriers. Shrub roses, such as *Rosa rugosa*, create an attractive, but impenetrable barrier, producing large red rose hips that contain 60 times the vitamin C of an orange. The hips can be used to make tea, jam, syrup or jelly. Currants and other fruit can also be included on the sunny side.

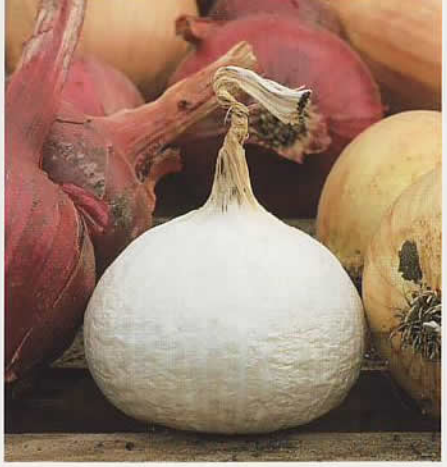
When designing your kitchen garden, bear in mind that the garden is for everyone in the household. Hold family discussions to involve everyone in the planning and design stage. It is worthwhile taking everyone's needs and tastes into consideration when undertaking this extremely important stage of development.



Right: *Cloches and low tunnels can increase the range of early crops that can be grown in the kitchen garden.*

CROP VARIETIES

There is a seemingly endless array of seeds available to the home gardener. Each supplier makes claims that their variety is better than all those that went before and any others currently available. Others claim to have older, more choice varieties saved from extinction and representing a time when everything was purer and more wholesome. Personal preference usually decides the best varieties for you, but an understanding of what you can expect from the seed in a packet can be very useful.



Above: *Onions come in a range of attractive colours and can be grown for their ornamental value in beds and borders.*

WHAT ARE HYBRIDS?

Often when we purchase seed, we respond more readily to the picture on the front of the packet. We may not notice whether it is marked with the terms "F1" or "hybrid". A hybrid is the result of a cross between one variety with pollen from another specific variety. The breeder chooses parent varieties that will produce first generation offspring (F1 hybrids) with known characteristics. The crossing is done in a very controlled manner so that no pollen from another variety is able to pollinate the flowers. As a result, all of the plants that are grown from the hybrid seed will be genetically identical.

Hybrids may be bred to be more widely adapted to environmental stresses such as heat, cold, disease or drought than non-hybrids. They also have more uniform characteristics, making crops more predictable in their qualities. They also have "hybrid vigour" and may grow faster or be more disease-resistant than either of the parents. They may also give better yields than open-pollinated varieties. They will not breed true, however, meaning that seed collected will not produce plants that are the same as the parent (F1 hybrids). For this reason, seed cannot be saved from F1 hybrid plants by the home gardener. Seed for hybrid varieties must be purchased year after year from the seed companies or nurseries, unless you want to gamble and grow an array of offspring.

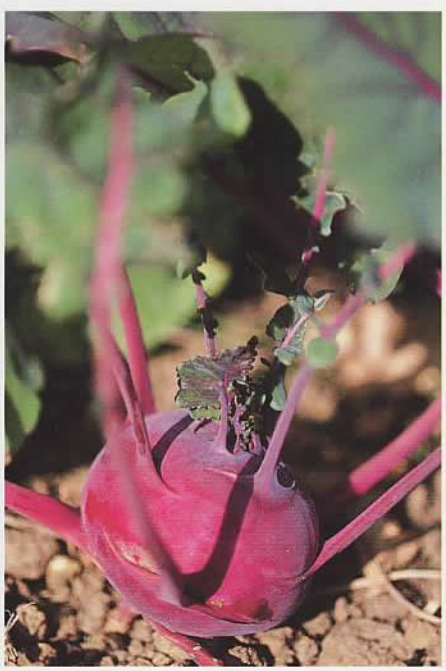
WHAT ARE OPEN-POLLINATED VARIETIES?

Open-pollinated varieties are traditional varieties that have (in some cases) been grown and selected for desirable traits such as taste, yield or disease-resistance for many years. They often grow well in organic kitchen gardens as many were originally selected under organic conditions. These plants can mutate and adapt to the local ecosystem, as the seed is often collected and re-used by the organic gardener.

If a seed packet is labelled "heirloom", "open-pollinated" or has no special markings, then it is most likely a standard or traditional variety. The majority of lettuce, bean and pea varieties for domestic use are open-pollinated, while most cabbages, broccoli, tomatoes, cucumbers, melons and Brussels sprouts are hybrids.

Hybrid seeds can dominate the garden seed market, but open-pollinated varieties are more or less stabilized in their characteristics, remaining fairly consistent and producing seed that will grow into plants that are more or less like the parent plants. They are a little less uniform than hybrids, but the home gardener can safely collect seed and grow plants from them that will be essentially the same as the original plants. Open-pollinated varieties either self-pollinate or are pollinated by wind or insects and they usually produce viable seed.

There have been various claims that open-pollinated varieties do not taste as good as hybrids. It is also claimed that they are smaller and not as uniform and, in many cases, this may be true. However, where matters of taste in varieties are concerned, the only real answer is to try them and see for yourself.

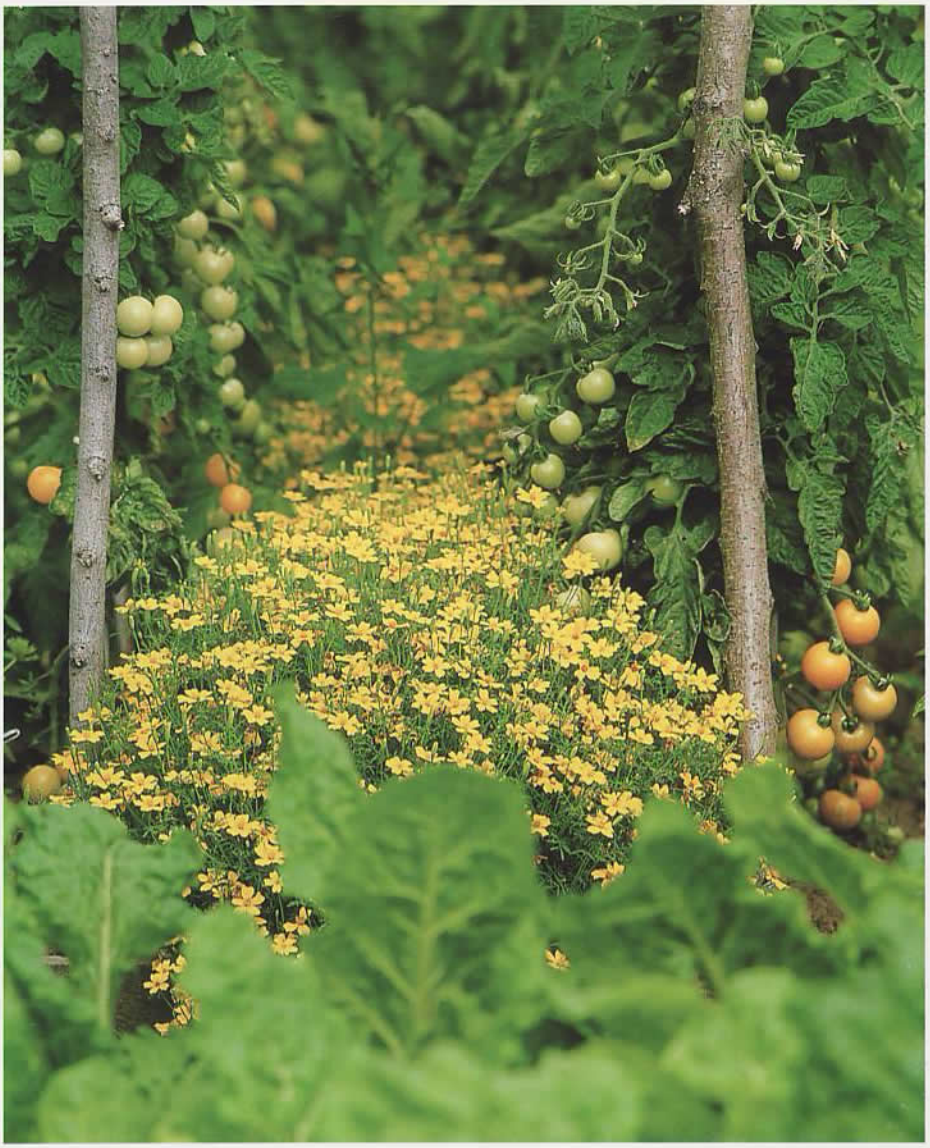


Right: *Allowing a few of your crops to flower will also provide you with seed for growing next year's crop.*



Left: *Unusual crop varieties can often be grown from seed that you have collected yourself each year. This is a striking variety of kohl rabi.*

Right: *Old varieties of tomato tend to have varying sizes of tastier fruits that crop over a long period of time.*



WHAT ARE HEIRLOOM VARIETIES?

In the 1970s the European Community brought in regulations to encourage the breeding of new vegetable cultivars and the standardization of older ones. This resulted in a list of approved cultivars being drawn up and it became illegal to sell any cultivar that was not included on this list. It is very expensive to have a single cultivar tested in order to then register it on the list. This meant that many old cultivars were put in grave danger of being lost forever, as the funds to test each variety were not available. It was due to this legislation that HDRA, the Organic Organisation, in England, a society which was established to promote organic issues, founded the Heritage Seed Library (HSL). This seed library ensures that old or "heirloom varieties" are kept safe for posterity by distributing its seed. Although HDRA grow some of the seeds themselves, they also employ contract growers and seed guardians to make up the bulk of the seeds that are supplied.

Each year a catalogue is sent to HSL members from which they can select up to six varieties free of charge. This distribution set-up overcomes the clause of selling only approved cultivars. This service is also available to members in the United States.



The best heirloom cultivars can be traced back fifty years or longer. Many of these early varieties have been lost already, making those that remain all the more precious. A number of these cultivars have been collected and saved by families and ethnic groups dating back many years. This practice protected the genetic make-up that made each variety successful within a given environment. These base characteristics have become invaluable and the genetic strains of these vegetables are the backbone of modern disease- and drought-resistant hybrids. It is this that makes the collection and preservation of these cultivars so important.

Left: *Many heirloom varieties have been selected for the way they perform in local garden conditions, rather than for crop size or uniformity.*

CROP ROTATION

This is the practice of grouping and growing related plants together and rotating them around different areas of land in a regimented fashion from year to year. Rotating your crops in this way has many advantages, including helping to prevent pest and disease problems from arising in the first place. This method of gardening is fundamental to successful organic growing. It has been practised for thousands of years and developed into a system that is easy to follow.



Above: *The secret to achieving a thriving and healthy kitchen garden is to rotate the crops on a regular basis.*

WHY ARE CROPS ROTATED?

Continuous cropping in the same area puts both plants and soil at risk. It not only allows large numbers of soil-borne pests and diseases to build up, but, because crops require the same nutrients from the soil year after year, the practice can deplete nutrient levels. A poor infertile soil produces weak unhealthy plants, which, in turn, will be more prone to pest and disease attacks. All these problems amount to reduced yields and even complete crop failure.

When crops are rotated, the groups are divided up into closely related plants that are prone to similar pests and diseases. For example, carrots, parsnips, beetroot and potatoes are members of one group and prone to carrot fly, whereas cabbage, kale, broccoli and Brussels sprouts, which are members of another group, can be prone to clubroot and cabbage root fly. If the groups are grown in different areas on a rotational basis, it can help to prevent the establishment of soil-borne pests and diseases.

Combined with regular additions of compost and manure, crop rotation will make the soil richer, replace certain nutrients and help prevent pH imbalances that can result from repeated crops of the same type of vegetable. Companion planting will also aid a rotational plan, particularly if the species improve pest control.

MAKING A ROTATIONAL PLAN

The basic rules of crop rotation are simple. If you are planning a four-year crop rotation, the plants you have selected are split up into five groups. Group one contains the legumes (peas and beans); group two contains the brassicas (cabbages, Brussels sprouts, broccoli, kale etc); group three contains the onion family and others (onions, lettuce, garlic, sweetcorn etc); group four includes root crops (potatoes, parsnips, carrots, beetroot etc); and finally group five houses permanent crops such as asparagus and rhubarb.

BENEFITS OF CROP ROTATION

There are many benefits to be gained from rotating your crops regularly.

- Prevents the build-up of soil pests and diseases
- Helps to prevent nutrient depletion from heavy-feeding crops
- Rotated crops produce higher yields
- Results in a healthier soil

The vegetable plot is then divided into five sections. The permanent crops are given a specific area and are not moved or included in the rotational cycle. The remaining four groups are allocated an area in which to grow. Every year each group is moved on to the next plot, making it four years before the crops are grown on the same area of land again; hence the name crop rotation.

If space is limited, crops can be grown on a three-year rotation. Quite simply, the crops are split into three groups, plus the permanent ones. The plant groups are divided up as before except group three is incorporated into group one.

There is no need to grow each crop in every year of a cycle. Remember that it is the vegetable groups that dictate the cropping cycle according to their soil needs and any associated problems. Rotating the crops helps provide the correct soil requirements for certain crops. For example, cabbages and the rest of the group grow well in soil that has been manured the previous autumn, whereas carrots and other root crops (not including potatoes) do not. Where carrots are to be grown, then the plot will need to be dug deeply in readiness for them.

It is important that you plan where the crops are to be every year, so that you know their position for the following year. A comprehensive cropping plan can help you to maximize the yield on a year-round basis by working out successional sowings and intercropping and catch cropping. The plan needs to include not only the crops that will be grown but also the companion plants and the soil amendments that are needed to support the best possible growth of your plants.

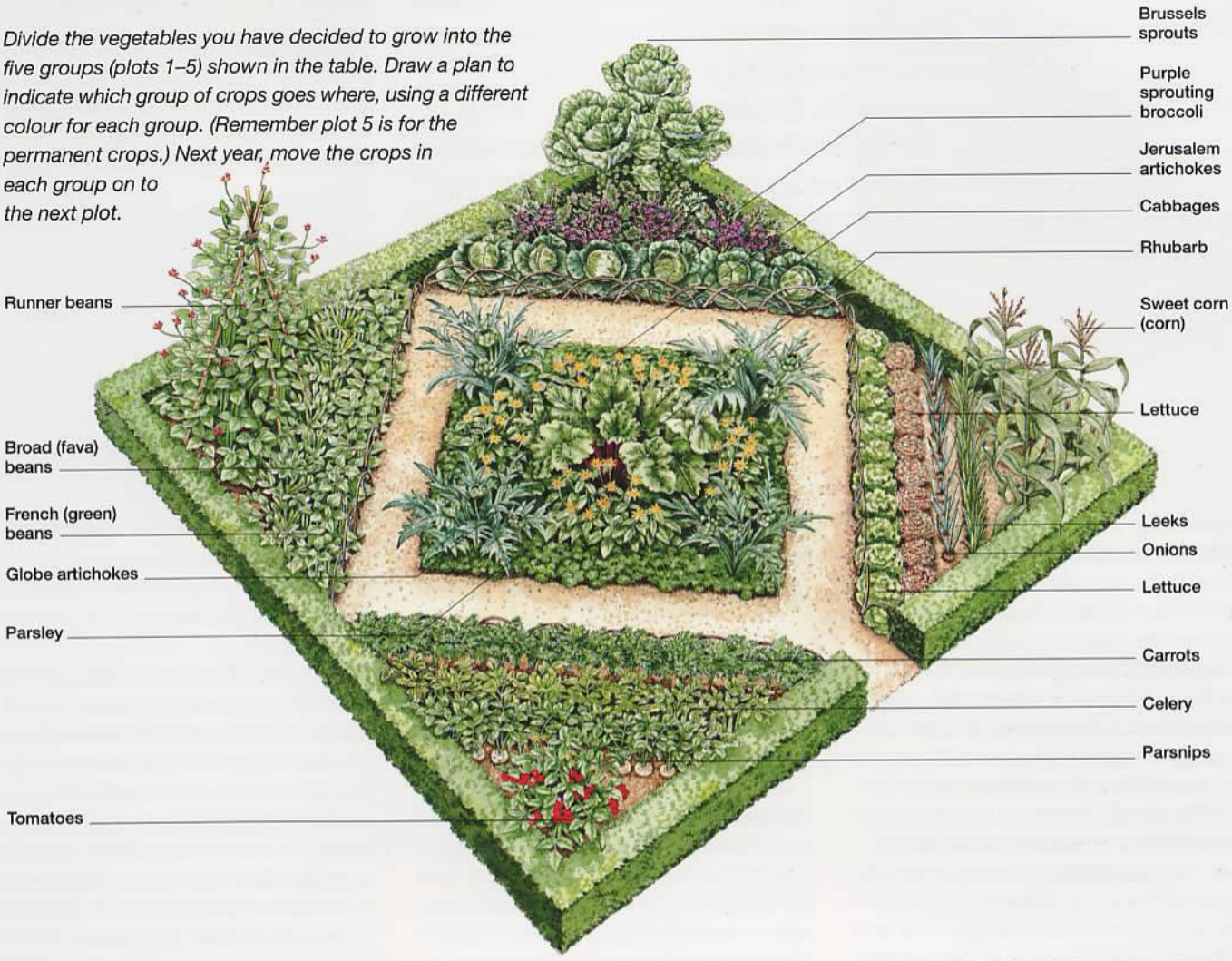
COMMON DIFFICULTIES

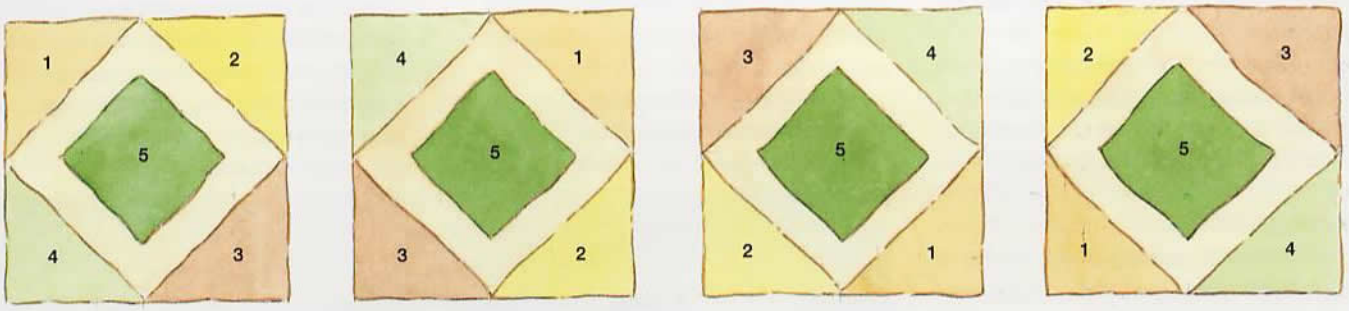
When planning the cycle, you may encounter certain problems. Careful planning will show that potatoes often take up more space in a vegetable bed than any other crop and finding enough room to grow them in their allocated area may prove difficult. Other problems you may come across include overwintering brassicas or plants left in the ground for seed collection. This is when you find that practising crop rotation in a small garden is difficult and that you may not be able to practise a strict rotation.

If space is proving a problem, consider some of the following strategies. Keep brassicas together as a group and never plant them in the same ground two years running. Keep potatoes together every year; if you have planned a lot of potatoes, move all the other members from group four into group three. Also bear in mind that some root crops, such as potatoes, are manure-friendly, while others, like parsnips, are not. Finally, alternating shallow-rooted plants like cabbages or lettuce with deep-rooted plants like tomatoes or squash will allow the plants' roots to do much of the soil loosening that would otherwise have to be done by hand. This will help to preserve the health of the soil, while causing minimal disturbance to its ecosystem.

FOUR-YEAR CROP ROTATION

Divide the vegetables you have decided to grow into the five groups (plots 1–5) shown in the table. Draw a plan to indicate which group of crops goes where, using a different colour for each group. (Remember plot 5 is for the permanent crops.) Next year, move the crops in each group on to the next plot.





YEAR ONE | YEAR TWO | YEAR THREE | YEAR FOUR

Plot 1
Peas
Broad (fava) beans
French (green) beans
Runner beans

Plot 2
Cabbages
Brussels sprouts
Calabrese (Italian sprouting broccoli)
Broccoli
Kale
Radishes
Swedes (rutabagas or yellow turnips)
Turnips
Kohl rabi

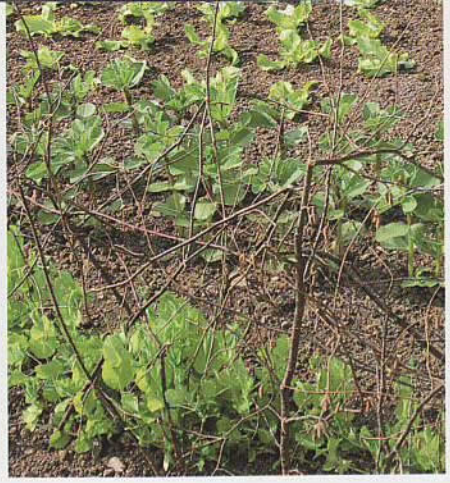
Plot 3
Bulb onions
Spring onions (scallions)
Shallots
Leeks
Garlic
Sweet corn (corn)
Marrows (zucchini), squashes and pumpkins
Lettuce

Plot 4
Potatoes
Parsnips
Beetroot (beets)
Carrots
Salsify
Scorzonera
Celery
Celeriac
Tomatoes

Plot 5
Rhubarb
Asparagus
Perennial herbs
Globe artichokes
Jerusalem artichokes
Seakale

GROWING METHODS

There are many different ways to grow your crops. You can try the traditionally practised method of sowing crops in rows or be more adventurous and grow them in blocks. The crops you have chosen to grow can be planted into a number of different types of vegetable bed: flat beds, raised or edged beds and no-dig beds. Each method and type of bed has its own advantages and disadvantages, which are described here, so choose the one that best suits your needs.



Above: *Twiggy sticks provide an ideal support for young climbers such as peas. They also look very decorative.*

PLANTING IN ROWS

This is the most traditionally practised and popular form of vegetable growing. It is an effective method because the spacing of the plants allows the crop to grow without excessive competition. In addition, it is relatively easy to add supports and protection such as cloches to the crops. However, this type of planting does have the disadvantage of needing relatively high maintenance. Due to the large amounts of bare earth left between the rows, the conditions are ideal for weed growth. Rows are spaced according to the optimum growth of the plants and so rows of pumpkins need to be much wider than those for carrots. Setting out rows in this way allows free movement of air along the rows. This results in fewer disease problems which can occur with more closely grown methods such as block plantings.

The rows are quite easily maintained by regular hoeing but can be wasteful of space, particularly in smaller gardens. They will produce sizeable vegetables, but this is offset by the actual yield per unit area being smaller than more intensive systems.

BLOCK PLANTING

In this method plants are grown in squares or rectangles rather than in straight rows. Blocks of plants are grown next to each other, for example in dimensions such as five plants by five plants. The numbers of plants grown can be larger or smaller than this. Block plantings use space efficiently, producing many more plants in an area than if grown in rows.

Well-tended soil can support planting that forms a close network of foliage over the soil. The soil will retain moisture extremely well underneath the canopy. It also stops weed seeds from germinating, resulting in a less weedy environment than other growing methods. However, a close canopy of leaves can have disavantages, resulting in poor air flow and high humidity which are ideal for attracting diseases such as botrytis. During dry spells watering is essential for the health of the crops. Double check all watering that has been done because water easily runs off the dense cover of the leaves and never reaches much of the root system.

Blocks can be planted and managed at ground level or in slightly raised beds. They suit modestly sized vegetables, such as root and salad crops, that are usually grown in rows. You may have to be inventive with crop protection for early-sown crops, as cloches and low polythene tunnels do not cover the area well. The blocks are edged with permanent paths for easy access to the centre from any side so you need never walk on freshly cultivated soil. As a result, the soil does not get compacted and the closely grouped plants make maintenance and cultivation easier.

Seeding a block involves sowing the furrows thinly along close rows. For example, instead of the usual 30–40cm (12–16in) distance between carrot rows, this can be reduced to 20–25cm (8–10in). Further space savings can result from growing as much as you can vertically, rather than sprawled over the ground. Wire fencing, netting or poles and tepees take up less space than blocks of climbing vegetables. This will also keep the climbing plants dry and free of disease.

FLAT BEDS

As the name suggests, flat beds are constructed at the natural ground level of your garden. They are the traditional way of cultivating ground for growing vegetables and are most suitable for gardens that have good soil. Flat beds will naturally raise the level of the soil, especially where organic matter is added on a regular basis as part of the cultivation regime, but the bed remains effectively at ground level. This form of gardening is relatively labour-intensive because all of the bed is cultivated, with large areas then being used as paths between the vegetables. With raised beds, there are no paths and only the growing areas are dug.



Left: *The close planting of crops in rows or blocks helps to retain soil moisture as well as reduce the growth of weeds.*



Above: *Plants such as beans can be trained over an arch in order to provide an ornamental and productive feature.*

RAISED AND EDGED BEDS

These can be freestanding garden beds or beds with wooden or brick walls constructed several inches above the normal ground level. Raised bed gardens not only look good but they also can help solve many problems associated with soils that are difficult to manage. Problems with soil are often aggravated in urban and suburban settings, where topsoil and vegetation may have been removed or the surface level changed during building work.

Raised bed gardens improve the environment for plants by lifting their roots above poor soil. The growing medium can be amended by the incorporation of manure and/or garden compost. Soil in these beds warms up earlier in the spring, allowing the seed sown to germinate quicker than if it is grown in flat beds. Beds should be located where they will receive full sun and with protection from prevailing winds. Do not site the beds in frost pockets or where air circulation is poor.

Drainage is important. Build the beds so that the crops will not become waterlogged, as good drainage is especially important when growing vegetables. If the bed contains clay soil, incorporate sand, grit or organic matter to improve drainage. Construct the bed so that it slopes about 2cm (¾in) per metre (yard) of horizontal distance away from any structures, or away from the centre of the bed.

NO-DIG BEDS

As the term suggests, no digging is involved in this method, which is a good way to retain good soil structure within a vegetable garden. Weeding is kept to a minimum and because the soil is not disturbed it will be alive with worms and other organisms. The bed is made on top of the ground and can be built over existing beds, lawns and even hard or rocky ground. Situate the bed in a sunny area that receives morning sun and has good drainage. It can be any size or shape, depending on your space. Start with a small bed – about 2 x 1.5m (6½ x 5ft) – but with a view to expanding in time.

When preparing the site it is not necessary to pull up the lawn or existing garden if the soil conditions are good, but if the ground is very poor, compacted or the drainage is bad, initial digging may be necessary.





Above: *Containers are an ideal way to grow a variety of crops where space is limited. These pots contain courgettes (zucchini).*

The outside wall of a no-dig bed is formed using logs, old planks, tiles, bricks or stones. Line the bed with a layer of plain wet newspaper, at least 6mm (¼in) thick. This layer should cover the enclosed area completely and overlap slightly, so as to kill off any weeds and stop new ones growing. Spread out a thin layer of hay or straw, ensuring that there are no gaps. Place a layer of good organic fertilizer, such as chicken manure, 20mm (¾in) thick, on top. Cover with a 20cm (8in) thick layer of loose bedding straw. Follow this with a 2cm (¾in) layer of good organic fertilizer and complete the bed with a top layer of garden compost, about 10cm (4in) thick. Make sure the bed is watered in well. Once it is settled you can plant out seedlings, but not seeds. Sowing seeds can begin when the bed has matured and the soil has become fine and crumbly.

No-dig beds that have been recently created are best for growing crops such as potatoes, lettuce, brassicas and cucurbits, whereas root crops grow better when the bed is mature. No-dig beds are best suited to planting vegetables in small blocks of different varieties rather than in long rows.

Left: *Vegetable beds need not be rectangular to be functional. This kitchen garden uses simple geometric shapes to provide interesting effects.*

COMPANION PLANTING

This is when two or more crops are grown together for the benefit of one or all. This technique creates a colourful landscape, made up of different species, which mirrors nature itself. Plants are grown together for several reasons, including to attract beneficial insects or to give off odours that deter or confuse pests. This is so different from large fields planted with only one crop, a monoculture that allows large numbers of pests and diseases to build up rapidly.



Above: *Nasturtiums have edible leaves and flowers as well as being a colourful companion plant.*

HOW COMPANION PLANTING WORKS

Plants have natural affinities with others of their kind. The smell of volatile oils from many plants discourages certain pests, making them excellent companion plants. A good example of this is the well-known relationship between the tomato plant and the French marigold (*Tagetes patula*). The scent of the French marigold is said to deter whitefly from entering the greenhouse and therefore avoids a whitefly attack on the tomato plant.

Plants such as yarrow (*Achillea*) and hyssop (*Hyssopus*) are just a couple of plants from a list of many that attract beneficial insects like hoverflies. The hoverflies will lay their eggs around these plants and, after hatching, the larval stage of the insect will start to eat adult aphids. So greedy are these larvae that they can eat up to 800 aphids before pupating. Many organic gardeners grow trays of single-flowered French marigolds to dot around their gardens, both in the vegetable and ornamental areas, in order to encourage these eating machines. This is both very effective and quite stunning to look at.

Certain distinct qualities of a plant have a proven benefit to others, such as fixing nitrogen in the soil. Clover in grass will fix nitrogen, offering the excess nitrogen produced to the surrounding grass which improves the yield. By the same token, others are less suited as partners. It is never wise, for example, to plant two vegetables side by side that attract the same pests, as this effectively doubles the chances of attack. It is advisable to practise crop rotation or use companion planting in between them.

BENEFITS OF COMPANION PLANTING

A mosaic of plants offers many benefits to the organic garden, some of which are outlined below.

- Creates a colourful landscape.
- Plants can attract benefical insects.
- Plant odour can deter harmful insects.
- A variety of plants together confuses pests from locating host plants.
- Plants attract birds that prey on pests.
- Flowers attract pollinators.

BENEFICIAL COMBINATIONS

There is little scientific evidence of these associations working, but if you talk to any organic practitioner, they will certainly provide plenty of anecdotal evidence. Tomatoes, for instance, like to be grown near basil and parsley plants. This is, of course, useful for cooks as well as gardeners. Separating rows of cabbages, broccoli or other brassicas with rows of onions has always been a popular combination, possibly due to the onion's strong scent confusing cabbage pests. Tomato plants also grow well next to cabbages and seem to deter caterpillars. Other beneficial combinations include leeks near carrots as they repel carrot flies, while Swiss chard thrives near carrots and beetroot. Never plant carrot and dill close by each other. This makes the carrots woodier and stronger-flavoured, and the dill milder and with weaker stems.



Right: *Companion plants can provide welcome splashes of colour in the kitchen garden.*

DECORATIVE COMPANION PLANTS

Certain flowers and flowering herbs offer potential benefits for a variety of vegetables. French marigolds (*Tagetes patula*) are cited as a wonder flower by many organic gardeners and the bright flowers make a colourful companion crop. They deter many pests, and seem to spur growth in roses. They are also said to reduce the number of soil nematodes, while attracting hoverflies and their larvae which eat aphids. French marigolds are frequently planted with pot marigolds (*Calendula officinalis*).

CROPS AND THEIR COMPANION PLANTS

While it is not an exact science, any practitioner of companion planting will tell you that individual crops have their "preferred companions". Experience is the best guide, but the list below outlines some plant combinations that work well in most situations.

Apples Chives, foxgloves, wallflowers, nasturtiums, garlic, onions
Apricots Basil, tansy, wormwood
Asparagus Tomatoes, parsley, basil
Beans Carrots, cucumbers, cabbages, lettuce, peas, parsley, cauliflower, spinach, summer savory
Beans (broad/fava) Potatoes, sweetcorn (corn).
Beans (dwarf) Beetroot, potatoes
Beetroot Onions, kohl rabi, lettuce, cabbage, dwarf beans
Brussels sprouts Nasturtiums
Cabbages Beans, beetroot, celery, mint, thyme, sage, onions, rosemary, dill, potatoes, chamomile, oregano, hyssop, wormwood, nasturtiums, tansy, coriander (cilantro)
Carrots Peas, radishes, lettuce, chives, sage, onions, leeks
Cauliflowers Celery, beans, tansy, nasturtium
Celery Tomatoes, dill, beans, leeks, cabbage, cauliflowers
Chives Parsley, apples, carrots, tomatoes
Courgette (zucchini) Nasturtiums
Cucumbers Potatoes (early crop only), beans, celery, lettuce, sweetcorn, Savoy cabbages, sunflowers, nasturtiums
Kohl rabi Beetroot, onions
Garlic Roses, apples, peaches
Grapevines Geraniums, mulberries, hyssop, basil, tansy
Leeks Carrots, celery
Lettuce Carrots, onions, strawberries, beetroot, cabbages, radishes, tagetes
Onions Carrots, beetroot, lettuce, chamomile, kohl rabi, courgettes
Parsnips Peas, potatoes, peppers, beans, radishes, garlic
Peaches Tansy, garlic, basil, wormwood
Peas Potatoes, radishes, carrots, turnips
Potatoes Peas, beans, cabbage, sweetcorn, broad beans, green beans, nasturtium, marigolds, foxgloves, horseradish, aubergine (eggplant)
Pumpkin Sweetcorn
Radishes Lettuces, peas, chervil, nasturtium
Raspberries Tansy
Spinach Strawberries
Squash Sunflowers
Strawberries Borage, lettuce, spinach, sage, pyrethrum
Sunflowers Squash, cucumber
Sweetcorn (corn) Broad beans, potatoes, melons, tomatoes, cucumber, squash, tansy
Tomatoes Asparagus, celery, parsley, basil, carrots, chives, marigolds, foxgloves, garlic, sweetcorn
Turnips Peas, nasturtiums



Left: *Foxgloves (*Digitalis*) make excellent companion plants for growing under apple trees.*

White alyssum (*Lobularia maritima*), by reseeding frequently, helps to break up the soil and adds to its organic content, while chrysanthemums reduce nematodes, making for healthier soil. Mint almost always works with various types of squashes and brassicas to aid plant growth, although it can become invasive. Tansy (*Tanacetum vulgare*) is said to repel ants, aphids and plant beetles although this, too, can become invasive if not regularly checked.

Chamomile (*Chamaemelum nobile*) is known as the "plant doctor" by some organic gardeners because of its alleged ability to encourage other plants to increase their production of essential oil, making plants such as rosemary and lavender taste and smell stronger. Chamomile is easy to grow and looks beautiful anywhere, although it should be kept well trimmed to avoid a straggly look. It is also thought that chamomile can help to activate the composting process if it is added to the compost heap.

Lavender (*Lavandula*) is a general insect repellent and makes an excellent small hedge. It is a great addition to the garden, attracting bees and numerous white and blue butterflies.

Plants that produce berries such as cotoneaster and the rowan tree (*Sorbus*) will attract birds into the garden. Birds, in turn, eat many pests, such as protein-rich aphids, caterpillars and various flies. Thrushes are the unsung heroes of the garden because they decrease the snail population quite considerably.

Be prepared to experiment before committing to a companion species. Nasturtiums have been cited as an effective aphid control, although many wonder if they do this by attracting all the aphids to themselves. What works in one area may not always work elsewhere and experimentation is the key to success in this interesting yet uncertain area of organic gardening.

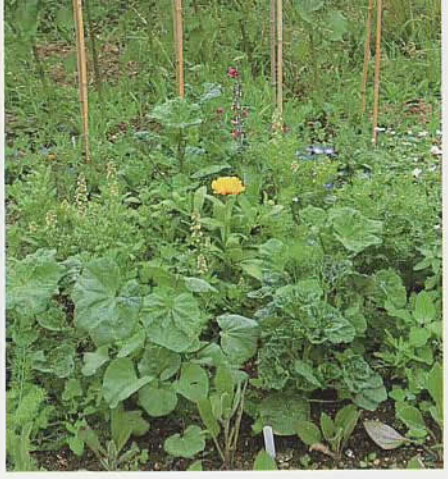
CROPS AND THEIR ANTAGONISTS

Some plants are highly antagonistic to one another. You should always avoid planting the following combinations.

Asparagus Onion and potato
Beans Chives, fennel or garlic
Carrots Dill
Carrots, cauliflower or potatoes Tomatoes
Peas Onion, garlic and shallots
Potato Pumpkin and summer squash

MAKING THE MOST OF YOUR SPACE

There are three basic growing techniques that you can use to make the most of your space. These are known as intercropping, catch cropping and successional sowing. By adopting the latter two practices, you will extend the cropping season instead of harvesting a crop all at once. You will also make use of the available space, therefore increasing yields. All that is needed is careful planning to work out which crops to sow and when.



Above: *Close planting in blocks makes the most of available space and allows more crops to be raised in a season.*

INTERCROPPING

This kitchen-garden technique increases productivity and also helps to keep the numbers of weeds down. It refers to the practice of planting a fast-growing crop, such as carrots, radishes and lettuce, between main crops that are slower growing. These include vegetables such as cabbages, peas and potatoes.

Intercropping involves harvesting the quicker-growing crop first before the slower-growing one achieves total foliage cover of the soil or shades out the area. A good example of intercropping is to grow a crop of spring onions or lettuce between tomatoes. Similarly, spinach or radishes can easily be planted out early between sweetcorn or, alternatively, radishes can be planted between cabbages.

Intercropping can also be used to increase productivity. It ensures that no space is left unused and makes the most efficient use of light, nutrients and moisture. It will also reduce the amount of weeds in the vegetable patch by maintaining a continuous plant canopy over the soil.

One slight variation on the theme is to combine the benefits of a green manure with a crop. This can be useful in the case of winter crops because the green manure doubles up as a cover crop, protecting the soil from erosion and leaching as well as stabilizing soil temperatures. If a leguminous green manure is planted in late summer or early autumn in a bed along with leafy crops such as Brussels sprouts, it can provide nitrogen throughout the remaining growing season. It will also provide a boost for early crops that will be planted out after the green manure crop has been dug into the soil. While intercropping requires careful planning, it can increase the productivity of even a relatively small vegetable plot.

CATCH CROPPING

This technique is when fast-maturing vegetables, such as radishes and lettuce, are grown in an area of ground that has just been cropped and has a vacancy until the next crop is either sown or planted. The sowing of the catch crops can be done in between the main ones or after harvesting at the end of the season if there is time. It is important to know how long a crop takes to mature when planning catch cropping so that you do not sow anything that takes too long to mature in between the main crops.



Left: *Successional sowing in rows allows the same space in the vegetable plot to be kept productive throughout the growing season.*

ADVANTAGES OF INTERCROPPING AND CATCH CROPPING

Making the most of your space is not only productive, but it also has environmental advantages.

- Suppresses weed growth in the kitchen garden
- Increases the productivity of the vegetable patch
- Planting green manures enriches the soil with nitrogen
- Helps to protect against the erosion of the soil
- Helps prevent leaching



Above: *The close spacing of rows and successional sowing of new rows allows the maximum use of space on your plot.*

SUCCESSIONAL SOWING

This is the practice of sowing the seeds of fast-maturing vegetables at regular intervals several times during the growing season. This practice will ensure that you have a continuous supply of crops such as lettuces, carrots and spinach throughout the season. Successional sowing is also useful where crops are sown directly outdoors early in the season where they may be prone to frost damage. Early crops such as lettuce and radish can be sown under the cover of, for example, a cloche where they will begin to develop earlier than would otherwise be possible. Subsequent sowings outdoors will mature later, thus extending the growing season for harvesting.

Gardeners with small plots can use this method by sowing only a half a row at any one time. This process is then repeated a week or so later, with further sowings as often as you like. This way you will have fresh vegetables for several weeks and will avoid a sudden glut.



Above: *Sweetcorn (corn) is a late-maturing crop that can be intercropped with fast-growing, early salad crops. This enables you to make the most of your growing space.*

FAST-GROWING CROPS SUITABLE FOR INTERCROPPING AND CATCH CROPPING

Use all the available space by sowing vigorous growing crops in between rows of the main crops. The list below shows the time it takes some fast-growing crops to mature.

Carrots	9 to 20 weeks
Endives	7 to 13 weeks
Lettuce	4 to 14 weeks
Radishes	4 to 8 weeks
Rocket (arugula)	3 to 5 weeks
Salad leaves	4 to 14 weeks
Spinach	5 to 10 weeks
Spring onions	8 to 10 weeks

CROPS SUITABLE FOR SUCCESSIONAL SOWING

The technique of successional sowing can ensure a continuous supply of fresh vegetables. It also increases the productivity of the garden and avoids harvest gluts.

Beetroot	Spring to summer
Broccoli	Spring to summer
Cabbages	Spring to summer
Carrots	Spring to summer
Endives	Spring to summer
Kohl rabi	Winter to summer
Lettuce	Winter to summer
Parsnips	Winter to spring
Peas	All year round
Potatoes	Spring
Radishes	Winter to summer
Salad leaves	Spring to autumn
Salad rocket	Spring to autumn
Spinach	Spring to summer
Spring onions (scallions)	Spring to autumn
Swedes	Spring to summer
Swiss chard	Spring to summer
Turnips	Winter to spring

SOWING IN THE OPEN

There can be nothing more satisfying than sowing seeds and watching in anticipation for them to germinate. Watching the seedlings grow in your kitchen garden, making it come alive with leaves, flowers and insects is a fantastic experience. One of the drawbacks of sowing out in the open is that you are at the mercy of the weather, but you can manipulate your garden environment by using cloches, small plastic bottles and polythene tunnels to increase your chances of success.



Above: *A dibber (dibble) is a very helpful tool to use when you are transplanting seedlings outside.*

SITE REQUIREMENTS

If you are a novice kitchen gardener, be assured that sowing seed is easier than you may think. In order to germinate successfully seeds need water, air, a suitable temperature and a place into which they can root in order to support the top growth that will follow. For this reason, good soil preparation is everything to organic success. Most garden soils are able to supply all the necessary elements and only slight modifications are usually necessary. However, it is important that the ground is prepared in a way that will enable the seed to germinate evenly and grow in a uniform environment. The prior preparation of a seedbed can provide the seed with the environment that it needs and has the added bonus of making the task of seed sowing easier.

Preparing a seedbed is simple. Following cultivation, the ground is levelled using a rake, held at a shallow angle, to break down any large clods. The art of levelling is to keep the rake angle shallow and move the high spots over into the low spots with even strokes. Hold the rake firmly at the rear and let the shaft run smoothly through the front hand. All stones and large objects, including organic matter such as twigs or previous crop debris, should be removed by combing them out with the teeth of the rake, while holding the tool in a near vertical position. The soil is then firmed with light treading. A light shuffle across the bed is best. Once firmed, lightly rake the soil again at a shallow angle to produce a light "fluffy" surface that runs freely through the teeth of the rake. This is the perfect environment for sowing and growing seeds.

SEED REQUIREMENTS

The conditions that seeds require to germinate are easy and straightforward to create. A well-aerated moist soil environment is almost all that the seed needs. Most seeds will germinate quite successfully once the temperature gets above 7°C (45°F). Seeds carry their own food supply that provides them with everything they need for those first crucial days following germination. Once the plant begins to establish and grow, it needs soil-borne nutrients. This means that the soil in which it is growing needs to be of the right fertility for the plant. Poorer soils can benefit from the addition of a base dressing with fish, blood and bone prior to sowing to give the boost that the developing plant needs, although loamier soils need only be properly dug and prepared to support germination.

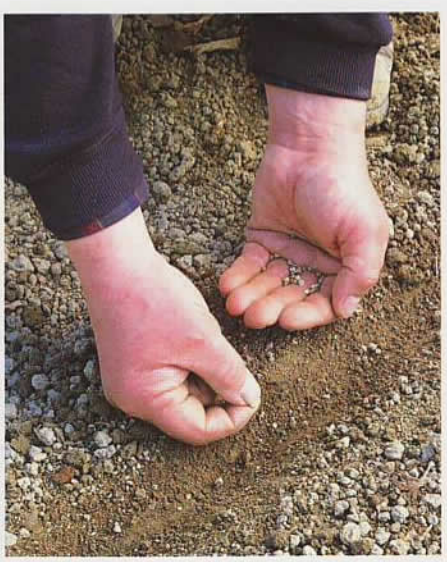
SOWING SEEDS OUTDOORS



1 *Set a tight string line where you intend your crop row to be and make a shallow drill with the edge of a swan-necked hoe.*



2 *Water dry soil using a watering can fitted with a fine rose about an hour before sowing and allow to drain.*



3 *Sow the seed thinly along the length of the row. Larger seed may be station sown at regular intervals.*

Some seeds can benefit from being soaked for a short period in tepid water just before planting to help them take on the water they need for germination. This is especially true of beets, but other large seeds also benefit from this treatment.

SOWING IN ROWS

Seed is usually sown in rows. Using a tightly drawn garden line as a guide, draw the corner of a swan-necked hoe along the line to create a shallow drill of about 1–2cm (⅜–¾in) depth, depending upon the seed's individual requirements. Dry ground can be watered after the drill is made. Sow the seed thinly and mix fine seed with silver sand to make it easier to distribute evenly. Mark the end of each row with a label before moving on to the next.

STATION SOWING

Seeds of larger growing plants, particularly those with seed that is large enough to handle, benefit from station sowing. This involves sowing two or three seeds at intervals that will be the eventual crop spacing. If all three germinate, then the two weaker ones are removed or transplanted to gaps where none has germinated.

WIDE ROWS

Certain seeds, particularly peas and beans, benefit from being planted in wide rows. Two rows are effectively station sown at



Left: *Station sowing is ideal for larger seeds or seedlings that resent disturbance. Use a marked stick to set the spacing of the seed.*

once, one on each side of a drill that is 15cm (6in) across. The drill is made with the flat of the hoe and after sowing the soil is carefully raked back. Make sure that you do not disturb the seeds from their stations.

BROADCASTING (BLOCKS)

Broadcasting is an ancient method of seed sowing that was used to sow large areas of crops. It involves a "broadcasting" action that separates the seed to an even spacing. The easiest way to do this in small vegetable plots is to split the seed into two halves, mixing small seed with fine sand. Scatter the seed carefully, letting it run from your hand in even arcs as you move your arm from side to side. Sow each half of the seed at a 90-degree angle to the other, thereby assuring an even distribution. Gently rake the seed in once sown and lightly water if needed.

PROTECTING SEEDLINGS

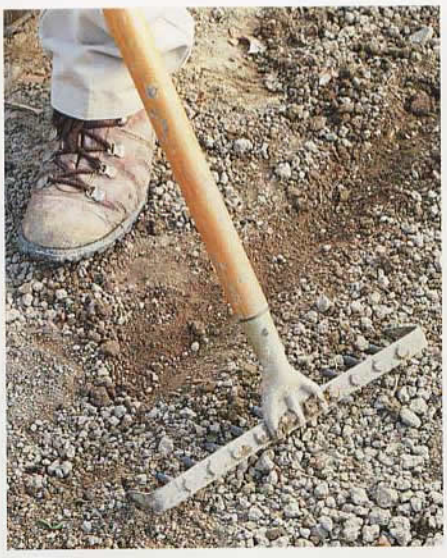
Seedbeds, with their fine "fluffed" earth, act as magnets to birds and animals. Some may take the seed from the ground, but, in truth, most will find it more attractive as a dust bath or litter tray. Once the seedlings emerge, however, some birds find them irresistible. They must be kept out with some form of barrier. One of the easiest methods is to form a low tunnel of chicken wire, supporting this on hoops. For larger areas, a series of stakes in the ground can be covered with netting to keep birds at bay. Sticks with thread or string stretched between them are also effective, but less easily removed for you to tend the crop.

LABELLING

When you sow a row or area of seeds, label it straightaway. Re-usable plastic labels are the best option. Each label should have the name and variety of the plant sown. You may also wish to record the sowing date and if the seed was pre-treated.



4 *Place a label at the end of each row, showing the crop name, variety and the sowing date, before you start a new one.*



5 *Gently cover the seed using a rake. Take care not to disturb or move the seed in the row when you cover it.*



6 *Alternatively, seed can be covered using a soil and potting mix. This is useful on heavy soils and avoids capping (surface hardening).*

SOWING UNDER GLASS

Sowing seed under glass extends the growing season and enables you to raise tender crops that only survive outside in warmer months. It is also ideal for rapidly establishing plants to use as catch crops and as early companion plants. In short, it offers variety and choice for your cropping regimes. Plants raised under glass can be grown on until they reach a size where they are better able to resist pest attack. They can also be planted out at their final spacing, thereby avoiding thinning or gaps in rows.



Above: *A propagator is a useful piece of equipment for raising your seed in ideal growing conditions.*

HEAT REQUIREMENTS

Most seeds have a preferred temperature range within which they will grow. A heated greenhouse, a conservatory or even a warm living room will often provide this, although seeds needing a constant high temperature may need a propagator. Such seeds are mercifully rare among vegetables, although cucumbers, tomatoes and peppers are good examples of crops that will benefit if they are first started off in a propagator.

CHOICE OF CONTAINER

There are a variety of containers that may be used to sow seed under glass. The most common form is the plastic seed tray which has now largely replaced the wooden seed tray. Although more attractive, wooden trays are difficult to keep clean and may harbour plant diseases. Plastic trays can be made of durable polyurethane or sometimes a more flimsy, thin, moulded plastic which is intended for single use. They are available in a variety of sizes, although small 9cm (3½in) pots may be more suitable when you are raising only a few plants.

Modular seed trays are another option. These are made up of individual cells, and a single seed is sown into each one. Seeds that are sown in these trays have the advantage of not suffering any root disturbance when they are planted out in their eventual position. The same is true of some biodegradable pots, which are formed out of paper and coir. These are better (environmentally speaking) than those made from peat, but any recycled material used for these trays is acceptable in the organic kitchen garden.

Inventive recycling can also provide an array of useful sowing containers. Re-using plastic cups, vegetable packing trays and



Left: *Many propagators have ventilators on the top in order to aid the flow of fresh air to the seedlings.*

any other throw-away items that might otherwise end up on a landfill site are all possibilities worth exploring. Old plastic bottles make good individual propagation cowls for small pots and plastic bags can also be used to cover the tops of pots and trays in order to maintain humidity.

PROPAGATORS

These are, in effect, mini-hothouses that help to keep the seed in a warm, moist, stable environment both above and below the soil line. Expensive propagators involve the use of electric soil-warming cables and some have thermostats to control the soil temperature. Many are designed for use in the greenhouse, but some models are narrow enough for use on a windowsill inside the house. Alternatively, instead of buying the whole propagator, you can purchase a heating mat on which the seed trays can stand in order to receive heat at the bottom. This system has the advantage of being mobile and easily moved about from area to area. Another cheaper method is to buy soil-heating cables to bed into sand. The seed trays sit on the bed of heated sand to receive an even supply of bottom heat.

AFTERCARE OF SEEDLINGS

Once seeds begin to germinate, they can be moved gradually into a less humid environment. The trays are freed of plastic covers, or the propagator vents or lids are opened and, after a few days, the lid is removed completely. As soon as the seedlings reach a size at which they can be handled, they are carefully pricked out into individual pots or larger boxes and trays. Always handle the seedlings by the leaves,



Above: *Modular trays are ideal for planting large seeds and avoid disturbance to roots when planting out or potting on.*



Above: *Individual pots can be used for large seeds. Plant two seeds per pot and remove the weaker seedling.*

SOWING IN TRAYS



1 *Fill a seed tray with propagation potting mix that has been thoroughly mixed. Fill the tray to overflowing and do not firm in the potting mix.*



2 *Using a straightedged piece of board, level the surface of the potting mix by carefully moving the board across the top of the tray.*



3 *Water the tray and leave to drain for about 20 minutes before sowing the seed on the moist surface of the potting mix.*



4 *Larger seed can be placed on the surface of the potting mix at regular intervals. Regular spacing will prevent overcrowding.*



5 *Once the seed has been sown, use a sieve to cover the surface with a fine layer of potting mix.*



6 *Do not cover the seeds of plants that require light for germination. Always check the growing requirements of plants before sowing the seed.*

gently lifting each one from beneath, using a dibber (dibble). Never hold them by the stems because this can cause a great deal of damage to the developing plant. They should be spaced at least 5cm (2in) apart to allow for subsequent development. Water the transplanted seedlings with a fine upturned rose attached to a watering can that has been filled with water overnight, thus bringing it up to room temperature and not giving the transplants a shock of cold water. Keep the seedlings on a warm and sheltered windowsill or in a greenhouse or conservatory. A constant temperature will promote healthy growth.



Above: *Growing vegetables in pots under glass can extend the growing season and also provide a colourful greenhouse display.*

HARDENING OFF

Plants that have been grown in a greenhouse cannot be put straight outside because their growth is too soft to withstand the cold. They must be gradually hardened off and acclimatized to outdoor conditions. The young plants are hardened off by moving them from the greenhouse and into a cold frame, planted out under cloches, low polythene tunnels or horticultural fleece. Open up the cloches and cold frames or remove the fleece during the day and replace at night for a week or two before planting out or removing the cloches completely. Remove low polythene tunnels after a couple of weeks depending on the weather conditions. If these are severe, leave in place for longer.



Above: *Watering from below by pouring the water into the base of the seed tray will prevent damage to newly emerging seed.*

THINNING AND TRANSPLANTING

Thinning seedlings not only allows the plants left in the soil to develop and mature into their natural shape and habit, but it is an essential process for good plant health. Thinned seedlings can be transplanted into bare areas or more often special seedbeds are set up or crops are grown under glass and the whole batch of seedlings are transplanted into their final destination within the vegetable garden.



Above: *Growing plants from seed is one of the most satisfying ways of producing new stock for the kitchen garden.*

WHY THIN SEEDLINGS?

All plants need space to develop and grow. Plants that are growing too closely compete not only for space, but also for light, water and important nutrients. In addition to this competitive stress, they also become prone to a variety of fungal diseases, as the air is not able to move around them. Thinning the seedlings helps to counteract these problems and will result in larger, stronger and healthier plants.

HOW TO THIN SEEDLINGS

Thinning is essentially two processes in one. Firstly, you are removing all the plants that are excess to requirements and at the same time you are selecting the biggest, healthiest and strongest plants that will be retained to form the crop.

Before starting to thin, dry ground must be watered, preferably the night before you intend to thin. A measuring stick, marked with the appropriate crop distance, can be used to show the approximate position of the individual plants. Remove all the plants in between each of the markers, selecting the healthiest plant at or near the mark on the stick. If there are no plants at the marked point, then you can transplant one of the seedlings that is excess to requirements into this position. When you are removing the excess plants, place a finger on the soil at either side of the seedling that is being kept. This protects it from root disturbance. Once you have finished, water the remaining seedlings with a fine rose on a watering can to re-firm the soil around the plants. The seedlings that have been removed can be put on the compost heap.



Left: *Seedlings grown elsewhere in the garden can be lifted and replanted in their eventual positions. This method is good for crops that need wide spacing.*



Above: *Rows of seedlings are often too crowded and need to be thinned when the plants are young.*

Avoid thinning with this method on hot dry days or in windy conditions, as the remaining seedlings may become water-stressed if their roots are disturbed. The alternative, in this case, is to snip off the seedlings at ground level with a pair of sharp scissors, thereby avoiding root disturbance.

THINNING DISTANCES

The following measurements are the distances that need to be left between thinned seedlings.

Beetroot	7.5–10cm (3–4in)
Broad beans (fava beans)	23cm (9in)
Carrots	7.5cm (3in)
Dwarf French beans (bush green beans)	20cm (8in)
Florence fennel	25cm (10in)
Kohl rabi	20cm (8in)
Lettuce	23cm (9in)
Parsley	15cm (6in)
Peas	5cm (2in)
Parsnips	15–20cm (6–9in)
Radishes	2.5–5cm (1–2in)
Runner beans	25–30cm (10–12in)
Salsify	15cm (6in)
Scorzonera	15cm (6in)
Spinach	15cm (6in)
Spring onions (scallions)	5cm (2in)
Swedes (rutabaga or yellow turnip)	30cm (12in)
Swiss chard	30cm (12in)
Turnips	15–20cm (6–8in)

TRANSPLANTING SEEDLINGS



1 *Water your row of seedlings at least an hour before transplanting and preferably the night before if no rain has fallen.*



2 *Using a fork to loosen the soil, gently lift the seedlings. Take care to handle them by their leaves and never touch the stems.*



3 *Using a tight line, straight edge or notched planting board, replant the seedlings at the appropriate spacing for that crop.*



4 *Gently water the seedlings immediately after sowing. Never let roots dry out at any stage during transplanting.*

TRANSPLANTING SEEDLINGS

The most common way of transplanting seedlings involves planting container-grown plants into open ground. Early vegetable crops can easily be raised in this way. The other method is to raise seedlings in open ground near to where they are to be planted out. Transplanting outdoor seedlings means that a smaller area of the vegetable plot is needed for sowing and, in consequence, a smaller seedbed is required. Transplanting seedlings is a good way of growing plants such as lettuce that are to be used in catch-cropping beds or where plants are to be planted out in no-dig beds.

The ideal time for transplanting outdoor seedlings is during damp overcast weather because this helps to prevent the seedlings' roots drying out. As is the case when thinning the plants, the seedlings will need watering the evening before. It is best to dig up only a few plants at a time, discarding any that are weak, damaged or appear to be sick. Seedlings can be placed in a plastic bag to maintain humidity around them while they are out of the ground.

A garden line can be set out in the vegetable patch in a similar manner to the way in which it is placed for preparing a seed drill. The position of the plants can then be determined using a measuring stick. Use a dibber (dibble) or thin trowel to plant the seedlings, firming lightly around the base before moving on to the next transplant. Once the row is completed, it is important that you water them in.

For catch cropping or planting among other plants, the surrounding crop may well determine the spacings between the transplants, although the procedure remains exactly the same.

COMMON PLANTING DISTANCES

Always allow the correct spacing between crop plants so that they will grow into healthy specimens.

Asparagus	30–38cm (12–15in)
Aubergines (eggplant)	60cm (24in)
Broccoli	60cm (24in)
Brussels sprouts	50–75cm (20–30in)
Cabbages	30–50cm (12–20in)
Calabrese (Italian sprouting broccoli)	15–23cm (6–9in)
Cauliflowers	50–75cm (20–30in)
Celeriac	30–38cm (12–15in)
Celery	23–30cm (9–12in)
Courgettes (zucchini)	60cm (24in)
Cucumbers	60cm (24in)
Garlic	15cm (6in)
Globe artichokes	75cm (30in)
Jerusalem artichokes	30cm (12in)
Kale	60cm (24in)
Leeks	15cm (6in)
Marrows (zucchini)	60cm (24in)
Onion sets	10cm (4in)
Peppers	45–60cm (18–24in)
Potatoes	30–38cm (12–15in)
Pumpkins	90–180cm (3–6ft)
Rhubarb	75–90cm (30–36in)
Runner beans	25–30cm (10–12in)
Seakale	30cm (12in)
Shallots	15–18cm (6–7in)
Sweetcorn (corn)	30cm (12in)
Tomatoes	60cm (24in)

AFTERCARE

The aftercare that your crops require is essential to ensure healthy plants that produce high yields. There are a number of different techniques that are listed below to help you on your way. Just remember that the more effort you put in then the better they will taste. As well as judicious watering and feeding, you will also have to weed the vegetable plot and provide some form of plant protection and support. But the reward of such care and attention is delicious home-grown produce.



Above: *Regular cropping of vegetables such as this ruby chard will encourage the development of new growth.*

WATERING

Vegetables need watering if there is no significant rainfall. This is especially true when the crops are young and only have shallow roots. Having a soil that is rich in organic matter is an advantage because it conserves water in the soil, particularly if the soil is sandy. You can enrich the soil by digging in organic matter, growing green manures or by continuous mulching.

If you have a large garden, mulching around the crop with straw, farmyard manure, garden compost or another similar substance can help to limit water loss. When you water, it is best to give the plants a thorough soaking, allowing the water to penetrate deeply. Giving a light watering will just encourage shallow surface roots that are easily damaged by prolonged drought. Prolonged dry periods also encourage plants to bolt, thus ruining the crop.

Certain plants such as cabbages and lettuces are naturally shallow rooted, whereas others such as tomatoes and squash are naturally deep rooted. Shallow rooters especially benefit from mulching and may need watering often in hot summers.

FEEDING

This is generally only necessary for heavier feeding plants such as pumpkins and marrows, but can provide a tonic for any crop during the growing season. Specific nutrient deficiencies are rare in the garden if a regular crop rotation and soil enrichment programme is followed, but if specific shortages are noticed, they must be countered immediately. Good liquid feeds can be made in your back garden. Try making compost tea or "worm liquid", as these are an excellent choice for actively growing plants.



Above: *The effort you put into protecting and caring for your crops will be rewarded at harvest time.*

Apply these feeds once every week or two. Many plants are given their main feed annually. This type of feeding is normally applied to fruit trees and bushes in the spring and is best applied in the form of a slower-release fertilizer such as bonemeal.



Above: *The careful harvesting of crops is essential if they are to store well. Here, carrots are being lifted with a garden fork.*



Above: *The regular harvesting of peas and beans will help to extend the length of the harvest period.*

WEEDING

Check your plants regularly and try to keep them as weed-free as possible. Remember that weeds compete with your plants for light, space, water and nutrients. It is better to weed a little and often than to weed irregularly. Even areas that have been mulched or have close cropping regimes need regular checks and weeds removed.

PLANT PROTECTION

Pests and diseases come in many different forms. Over time you will learn which specific problems your garden is prone to. Keep a yearly notebook of all the things that affect your crop each season, noting what control measures you used and how effective they were. In time you will have a record of how and when to manage pests and other problems in your own garden.



Above: *Taller plants and climbers will need some form of support. Canes or sticks with twine tied between them provide ideal temporary supports.*

PROVIDING SUPPORT

Plants may need supporting, especially climbers such as peas and beans. This support must begin at an early age, using twiggy pea sticks or hazel sticks, both of which can look ornate. Bamboo canes can be used for a host of climbing plants, but it is more ethically correct to use local materials rather than to use a product that has been transported thousands of miles. Squashes can be grown up fancy supports made from stakes and strong string or rope, making a curious garden feature. Other plants such as globe artichokes and Florence fennel can benefit from individual supports for their stems.

HARVESTING AND STORING

When harvesting, it is tempting to pick the good specimens and leave the rest, but remember to pick and compost poor or rotten ones as well as the best of the crop. Diseased or damaged crops can begin to rot and may infect the remaining harvest.

Freshly picked vegetables are higher in nutritional value than stored ones. So, during the growing season, pick what you need and store the surplus. Choosing when to pick a certain vegetable is a matter of taste. Some prefer to pick produce such as beans when they are young, small and succulent, whereas others prefer the beans to be more mature.

Crops can be stored in a number of ways. Root crops can be left in the ground in all but the coldest winters, lifting them as they are needed. Some crops, such as parsnips, actually develop a better taste after they have been subjected to frost. Alternatively, root crops can be stored in a cool dark place. They should be cleaned and stored in sand and a sterile organic substance such as coir, untreated sawdust, fine leaf mould, fine bark or sterilized soil.

Store other vegetables on shelves or boxes, ensuring that they do not touch. Onions and garlic are best kept in open sacks or in strings. Cabbages can be kept in nets until needed for up to two to three months. Other brassicas such as Brussels sprouts and swedes are best kept outside in the ground, harvesting them as needed.

Freezing is another storage option. Some vegetables, such as asparagus, beans and cauliflowers, are best blanched in boiling water for a couple of minutes before freezing. Alternatively, you can cook the vegetables and then freeze them, as is the case for marrows and Jerusalem artichokes.



Above: *Marrows and pumpkins are easily stored in trays that should then be kept in a cool dark place.*



Above: *Store root crops such as carrots in a cool dark place and cover them in sterile sawdust, leaf mould or coir.*

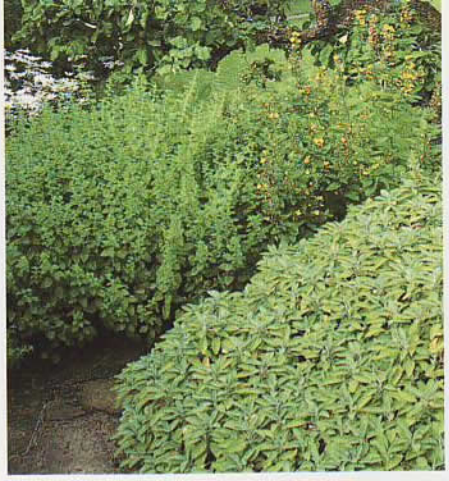
CROPS FOR STORING OVER WINTER

Harvest time often brings the problem of a crop glut. Storage can enable you to enjoy this bounty for longer.

Asparagus Best consumed fresh. Cook or blanch before freezing
Aubergines (eggplant) Cook before freezing
Beetroot (beets) Shelf storage or pickling
Broad (fava) beans Freezing or drying
Brussels sprouts Freezing. Leave on plant until needed
Cabbages Freezing or shelf storage. Leave in ground in mild conditions
Carrots Leave in ground in mild conditions. Shelf storage
Cauliflowers Blanch before freezing. Shelf storage if hung upside down in dark and misted
Celery Cook before freezing. Limited shelf storage
Courgettes (zucchini) Cook before freezing. Limited shelf storage
Dwarf French beans (bush green beans) Freezing
Garlic In sacks or strung
Kale Harvest through winter
Kohl rabi Leave in ground if mild or protected, medium shelf storage
Leeks Freezing, leave in ground in mild conditions, shelf storage
Marrows (zucchini) Cook before freezing, shelf storage
Onions In sacks or strung
Parsnips Leave in ground until needed or late winter
Peas Freezing or drying on plant
Peppers Blanch before freezing. Pickle or dry
Potatoes Store in paper sacks once cleaned and dried
Pumpkins Cook before freezing. Good shelf storage if fully ripe
Rhubarb Cook before freezing
Runner beans Freezing
Shallots In sacks or strung
Spinach Cook then freeze
Swedes (rutabaga or yellow turnip) Leave in ground until needed (may go woody by late winter)
Sweetcorn (corn) Freezing or pickling
Tomatoes Cook before freezing. Pickle
Turnips Leave in ground until needed

GROWING HERBS

Herbs are valued for their culinary, medicinal, decorative and aromatic properties. They come in a diverse range of sizes, shapes and habits, ranging from ground-creeping thyme through to the tall architectural stems of angelica. The choice of herbs is so great that there is always something to offer a gardener with only a window box, hanging basket or a small space. A herb garden offers a treat for the senses and these fragrant plants are also easy to grow in the organic garden.



Above: *Herbs are easy to grow given the right growing conditions. They provide an attractive, often fragrant, display.*

WHERE TO GROW HERBS

Herbs can be grown in a range of settings, such as custom-designed herb gardens and ornamental borders. They can also be grown as companion plants in the vegetable garden and are eminently suited to growing in containers, hanging baskets and window boxes. They are especially useful if grown near the kitchen.

Herbs range from tall showy herbaceous plants such as fennel (*Foeniculum vulgare*) and tansy (*Tanacetum vulgare*) to ground-hugging cushion plants such as thyme (*Thymus vulgaris*). The majority of herbs originate from dry sunny environments and so need sunshine to help them develop their essential oils. It is best to site herbs in an open, sunny spot in the garden where they will thrive.



Left: *Herbs are an important element in both ornamental and kitchen gardens, being decorative as well as useful.*

SOIL PREPARATION

Drier sites suit most herbs, and the sunnier and hotter the site the better they will taste. The taste and smell of herbs is usually due to the production of essential oils within the plants. If they are grown in hot conditions, then the concentrations of essential oils will be greater. Growing herbs in very moist rich soils can accelerate their growth, but will result in a milder flavour. They will also look better and flower less than their "hot-site" counterparts and be easier to harvest.

Herbs are, however, best grown in a soil that is loamy with some added organic matter. The ideal pH is 6.5 to 7.0, which means that herbs can easily be planted among vegetables in the kitchen garden.

SOWING HERB SEED

Herbs may be sown directly in the soil outdoors, just like vegetables. The preparation of the seedbed and the sowing techniques are exactly the same, and they can easily be interplanted or block planted among other vegetables.

Alternatively, herb seeds may be planted under cover, raising them in the same way as early vegetables and bedding plants and then hardening them off before planting out in the garden. This method is especially useful for more tender, leafy herbs such as basil or coriander (cilantro).



Above: *You can restrict the spread of invasive plants such as mint (*Mentha*) by planting them in pots or buckets that are then buried in the ground.*



Above: *Pinching out newly planted herbs such as this bay (*Laurus*) will encourage bushy, leafy growth.*

Basil (*Ocimum basilicum*), for example, associates well with outdoor tomatoes, both in the garden and in the kitchen. These can be planted out together from an indoor sowing and the crop will be mutually complementary. Indoor sowing can also provide you with herbs that can be cropped earlier in the season, effectively extending the useful life of your organic herb garden.

PLANTING HERBS



1 *Excavate a planting hole that is about a quarter to half as big again as the plant's rootball. Make sure it is deep enough.*



2 *Ensure that the top of the compost is the same level as the surrounding soil. Refill the gap around the rootball and firm the soil.*



3 *Water the plant immediately after planting. Keep the plant well watered until it is fully established into the surrounding soil.*

PLANTING HERBS IN THE GARDEN

Herbs can be sited anywhere in the garden as long as it is sunny. They have a range of forms and colours and often make valuable additions to the ornamental garden. Foxgloves (*Digitalis*), sage (*Salvia officinalis*) and the curry plant (*Helichrysum italicum*) are a few examples of herbs that can be used in annual and herbaceous borders as well as in the kitchen garden. Some herbs, such as mint (*Mentha*) and lemon balm (*Melissa officinalis*), can become very invasive if they are not contained in a pot or sunken sink when growing among other plants in an ornamental border. Remove the flower-heads from the mint before they have had a chance to seed, as the seed will germinate all over your border.

PLANTING HERBS IN CONTAINERS

Herbs make excellent subjects for use in pots and containers and are wonderful for patio gardens that catch plenty of summer sun, although you need to make sure that the potting mix never dries out. Raised beds, which provide good drainage, are also good areas for growing herbs. Always plant them in a free-draining potting mix that will not become waterlogged. There are numerous cultivars of culinary herbs that can be used for ornamental purposes, and groups of pot-grown herbs can be extremely decorative as well as supplying you with a range of fresh flavourings. Thyme, rosemary, lavender and sage are all good choices to grow in pots, either outdoors or on your windowsill.



Above: *Herbs are easily grown in a container which will provide an excellent focal point in the kitchen garden.*

Herb pots require little maintenance, save for watering and the occasional feed during the growing season. Most are rarely long term and are best restarted yearly or every other year. Herbs that are permanently in pots, such as bay trees, will need repotting every year. Spreading subjects like thyme can be lifted and both top-pruned and root-pruned prior to repotting.

Mint and other spreading herbaceous subjects may need dividing and repotting from time to time. This is done by splitting the crown of the plant into smaller pieces and then repotting one of these back into the container with some fresh potting mix. Dividing in this way is best performed annually for very vigorous herbs. Harvesting on a regular basis is often enough to control the growth of many potted herb arrangements (where a number are planted in one container), but a light trim may also be necessary from time to time.

Potted herbs may also be grown in the greenhouse to ensure a supply both earlier and later in the season. Try growing basil (*Ocimum basilicum*), coriander (cilantro; *Coriandrum sativum*), chives (*Allium schoenoprasum*) and dill (*Anethum graveolens*) in pots because this will save money if you spend a lot on fresh herbs. Pots raised under glass can be brought into the kitchen for ease of use. A series of successional sowings under glass will ensure that you have fresh herbs for most or even all of the year, both indoors and out.



Above: *Planting spreading herbs such as thyme (*Thymus*) in pots will help to control them and can also be decorative.*

HARVESTING AND STORING HERBS

Many commonly used culinary herbs such as basil, coriander (cilantro), chives and parsley can be grown indoors on a windowsill or conservatory during the cooler winter months if you have space. If you are not able to spare growing room for these, most are easily stored for use later. Herbs are easily harvested and most of the storage techniques are simple and straightforward.



Above: *Aromatic herbs such as rosemary (*Rosmarinus officinalis*) can be used to flavour bottles of olive oil.*

HOW TO HARVEST HERBS

Various parts of herbs, including the leaves, flowers, fruits and seeds, are gathered at different times, depending upon the plant and the part that provides the desirable properties. Annual leafy herbs such as basil (*Ocimum basilicum*) and parsley (*Petroselinum crispum*) should be carefully picked, never taking more than about 10 per cent of the growth in a single picking.

The same is true of perennials such as sage (*Salvia officinalis*), thyme (*Thymus vulgaris*) and rosemary (*Rosmarinus officinalis*) because severe pruning or over-stripping of the leaves will weaken the plant. It is important that you not remove more than one-third of the growth at any one time. If you harvest carefully, you will get a more vigorous leaf growth that will result in healthier plants.



Above: *The best time to harvest herbs is usually just before they flower. This is when they have their strongest flavour.*

As a general rule, pick herbs just before the plant is about to flower, which is when they have the strongest flavour. Pick the leaves when they are fresh and at their sweetest, selecting blemish-free, upper leaves. Collect the leaves in early morning or late evening, provided they are dry, rather than in bright afternoon sun when the plant's sap is rising. This is when the aroma of herbs is at its strongest and is easily lost if picked during this time of day. Flowers such as borage (*Borago officinalis*) and lavender (*Lavandula*), however, are best picked just before they reach full bloom and once they begin to open in the heat of the day.

Rhizomes, like ginger and turmeric, are collected in autumn, just as the leaves begin to change colour and the maximum amount of nutrition has been stored. Use a fork to gently free the roots from the soil and always avoid "hand-pulling" them. Choose only the best ones and use a vegetable brush to gently loosen any dirt. If you do need to wash them, do so quickly in cold water and avoid soaking them, as this can result in lost flavour.

Harvesting seeds tends to vary from plant to plant. Some seeds, like those of borage, simply fall to the ground as soon as they are ripe. Thyme seeds are very small and hard to see. Parsley and coriander seeds shake off very easily, and frequently the plants will have sown next year's crop for you before you realize they have gone to seed. One method of harvesting any seed that is difficult to collect is to tie a small paper bag over the flower head when the seeds start to form, ensuring that you can collect the seed without losing any. It would be advisable to use this method for collecting from plants with small seed as they can drop off when ripe or sometimes spring from the plant.



Above: *Herbs can be dried for later use by hanging them in bunches in a dry place out of direct sunlight.*

DRYING HERBS AND FLOWERS

Store herbs in a cool, dry place with minimum exposure to air and sunlight. One of the most popular methods of preserving them for use during the winter months is drying. This method can actually improve the flavour of some herbs, particularly the leaves of bay trees (*Laurus nobilis*). Herbs may be dried in bundles secured with a rubber band or string and hung upside down from a rack in a dry location such as an airing cupboard or shed.

When drying the herbs, the temperature of the area should not exceed 30°C (86°F) because the plants' essential oils will evaporate at or above this temperature. Do not dry your herbs in the kitchen where they will be spoiled by the humidity caused by cooking.

Fresh herbs can also be placed in brown paper bags. Remember to label the bags because it will be hard to distinguish between the herbs once they have dried. Store in a dry, dark, cool place until the herbs inside are dry, shaking the bags occasionally so that the plants dry evenly. Remove any stems and store the dried herbs in airtight jars. Keep the jars away from light to protect the colour and flavour of the herbs. Roots are best chopped into small pieces and dried in an oven. In general, you can expect those that you have grown and dried yourself to last at least two years.

STORING HERBS

Herbs can also be preserved in other ways, so that you can use them in cooking throughout the year.

Herb salts In a cool oven, spread a layer of ground salt on a sheet of greaseproof (waxed) paper. Sprinkle the chopped fresh herbs on top of the salt and bake for 10–20 minutes. When the herbs are dry, let them cool and place in a jar. Chives, oregano, thyme, lemon balm, lemon thyme, parsley, rosemary and basil can all be treated this way.

Puréeing This method involves mixing approximately 60ml (4tbsp) of olive oil with 2l (8 cups) fresh basil leaves which have been washed and dried. These are blended in a processor until puréed before being transferred to a jar. Stir each time you use it and top with a thin layer of oil afterwards. The purée should keep for up to one year in a refrigerator.



Above: *After herbs have been hung up to dry, separate the seeds from the dry flower heads before storing in tightly sealed jars.*

Freezing herbs Herbs such as dill, fennel, basil and parsley freeze well. The herbs should be cleaned and put into separate, labelled freezer bags. Alternatively, chop the leaves and freeze them with a little water in ice-cube trays. Chop the herbs finely, filling each cube, half with herbs and half with water, before freezing. Transfer the frozen cubes to plastic bags and label. Frozen herbs are best used within six months.

HERBAL INFUSIONS

You can also make a hot infusion of leafy herbs by placing the herb and any fine-quality olive oil in a glass bowl. This is then placed over a pan of gently simmering water and heated gently for about three hours, ensuring that the water in the pan does not dry out. The strained oil, once it has cooled, should be stored in airtight bottles or jars.

A cool infusion of flowery herbs involves using fresh herbs such as chamomile which are ground with a pestle and mortar and packed into a large jar and covered with oil. The sealed jar is then left in a warm, sunny place for two to three weeks and shaken occasionally. It is then strained and placed into airtight jars or bottles where it can be stored for up to a year.

A simple way of creating aromatic olive oil is to simply add a large sprig of your chosen herbs – rosemary and mint are good choices – to a bottle of olive oil. Store the bottle in a cool dark place for about ten days before using.

You can also make you own herbal vinegars by adding fresh herbs such as tarragon or rosemary or cloves of garlic, slices of ginger, chillies or peppercorns and all-spice powder to white vinegar. Crush about a quarter litre volume (1 cup) of loosely packed fresh herbs for each litre of vinegar. If you are using dried herbs, use half the amount of herb stated above. It is important that you use only commercially prepared vinegars, as homemade vinegar may not have a low enough pH to prevent bacterial growth. Place the vinegar in a pot on the stove and heat, but do not boil. Place the herbs in a clean, sterilized jar and slightly crush them. Pour the vinegar over the herbs and cover the jar tightly. Let the herb-vinegar mixture steep in a dark place at room temperature, shaking the jar every couple of days. After a week, strain the vinegar and place in bottles and store for up to six weeks.

DRYING AND FREEZING HERBS



1 *Pick seed just as it is ripening. Place the seeds on a tray or in a paper or muslin bag. Leave in a cool, dark place for a few days until the seed is completely dry.*



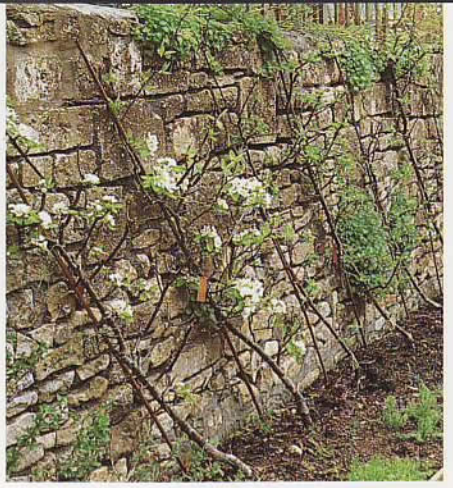
2 *Herb seeds that have been dried can be stored in old glass jars with an airtight lid. Store the jars in a cool, dry, dark place and label them for future reference.*



3 *Herbs can be frozen in ice-cube trays. Fill the trays with water after you have added the herbs to make ready-to-use cubes. Herbs can also be packed into freezer bags.*

GROWING FRUIT TREES AND BUSHES

Freshly picked fruit from the organic garden tastes absolutely delicious. The warm taste of a juicy sweet raspberry or the crisp flavour of a tree-ripened apple would tempt many a gardener into growing their own fruit produce. The tastes can be quite different from shop-grown produce where storage, handling, packing and off-the-tree ripening all take their toll on the quality and taste of the fruit.



Above: *A sunny wall provides an ideal location for growing fruit trees, such as this pear, that need warmth.*

WHERE CAN FRUIT BE GROWN?

Fruit trees and bushes can be grown wherever there is space. Strawberries can be used in hanging baskets or tubs, dwarf apple trees can be planted in ornamental containers and a number of fruits, such as cherries, white and red currants and figs, can all be grown against walls. Fruits not only provide produce for the kitchen table but many of them have ornamental qualities and can blend well with other plants in the decorative garden.

CHOOSING A SITE

The best site for fruit, both indoors and out, is a sunny one. Sunlight is essential, not just for the ripening of the fruit itself but also for flower bud formation and flowering. In addition, fruit trees and bushes often appreciate a sheltered spot where even exotic fruit can be raised. Within the garden a sheltered sunny wall can provide the ideal place to grow peaches, apricots or figs. If cold winters are a problem, then provide winter protection in the form of a portable frame or, alternatively, grow the plants in a greenhouse. It is worth noting that providing your plants with the ideal conditions for healthy growth will reap its rewards in the end. Not only will you harvest heavier yields, but, more importantly, your plants will be less prone to pest and disease attacks, which is an obvious advantage when growing organically.



Left: *Most fruit bushes will benefit from a generous application of well-rotted manure or compost early in the year.*

SELECTING THE RIGHT PLANTS

Variety selection should not be based purely on hardiness but on personal preference. You may also wish to consider how easy the fruit tree or bush is to grow, fruit size, taste and the time of harvest. Selecting more than one variety can result in having fresh fruit over a longer period due to a succession of ripening.

Some fruit trees combine the best qualities of two plants. Grafting utilizes the qualities of the variety as top growth (scion) and other desirable qualities from a rootstock that may be absent from the variety. The scion is the fruiting variety that is budded or grafted on to the rootstock which is selected for certain characteristics such as dwarfing, nematode insect resistance, soil type, cold hardiness and disease resistance.

The most commonly grown rootstocks for amateur gardeners are the apple semi-dwarfs and dwarfs. Grapes are also grafted on to clonal rootstocks, although they are often supplied on their own roots. Figs, olives and various types of berry are also usually supplied as plants on their own roots.

Dwarf apple trees are very useful in small gardens and are eminently suited to container growing. They produce fruit of the same size, colour and quality as larger standard trees and require the same pruning, nutritional and care regimes as a standard-size tree.

Dwarf trees fruit much sooner after planting and bear less fruit per tree. When harvesting the fruit, you can reach all parts of the tree from the ground without using a ladder and the trees are easier to train and prune on an annual basis. Grafting the desired variety on to special clonal rootstocks "dwarfs" apples. The most popular dwarfing rootstocks for apple were developed in England and are designated as either EM or M (for East Malling) or MM (for Malling Merton). Dwarfed trees must be pruned annually or size control may be lost. In addition, loss of fruit by frost or pests will also increase growth so necessitating summer pruning.

PLANTING FRUIT TREES AND BUSHES

As with any other type of tree, good ground preparation and careful handling are essential steps to successfully establishing your fruit trees and bushes. The cheapest option when buying fruit trees is to purchase bare-rooted plants. The disadvantage is that they are only available during the dormant season. The most important factor in handling bare-rooted plants is not to let the roots dry out. When you buy trees always check the condition of the roots and packing material. Heel in plants by covering the roots with moist soil in a cool environment outdoors if they are not to be planted immediately.

Dig a hole slightly wider and deeper than the spread and length of the root system, making sure the sides of the hole are not "glazed" over as this will result in a root girdling. After trimming diseased, dead, broken or extra long roots, place the tree in the hole and spread out the roots. For larger trees, place the stake in the hole and drive it in (remembering to first remove the tree and cover the roots). Place the tree back into

PLANTING A FRUIT TREE



1 *Dig a hole in the ground that is at least half as large again as the rootball of the fruit tree. Loosen the sides and the base of the planting hole with a garden fork.*



2 *Remove the pot and check the rootball for girdling roots. Tease these out by hand or with a garden fork.*



3 *Use a straightedge to make sure that the plant is at the right depth in the hole. Fill around the roots with soil, firm it down and water well.*



4 *Hammer in a stake at an angle of about 60° in order to avoid the rootball and place a tie on the tree. Saw off the end of the stake. Nail the tie to the stake to secure it.*

5 *The tree should remain staked for approximately one year. As the diameter of the tree stem increases, loosen the tree tie as required.*



the hole and return the soil, firming in layers of about 30cm (12in) as you go. This avoids large air spaces being left around the roots and ensures that it is set firmly. Trees should be planted at the same depth as they were grown in the nursery. Make sure the bud union (for trees on rootstocks) is about 5–7cm (2–2¾in) above the soil line. Do not place fertilizer in the planting hole as this can be added later. Mulch the newly planted tree with well-rotted manure or compost to suppress weeds. Container-grown nursery stock can be transplanted any time of the year. Site preparation is the same as for bare-rooted stock. Make sure that you check the roots as they can become distorted or root bound if they are grown in containers for a long period of time. Teasing these roots out can help avoid root girdling, but the best way to do this is to use field-grown (bare-rooted) stock.

PRUNING NEWLY PLANTED STOCK

Fruit trees must be pruned when they are planted for a number of reasons. If planting bare-rooted stock, the top of the tree must be pruned to counter-balance the loss of the root system which would have been severed in the nursery during lifting. Pruning also forces the growth of laterals from which the future framework of the fruit tree will be selected. Branches that are desirably located can be retained as part of the framework whereas undesirable branches are removed.

FRUIT TREE POLLINATION

Pollination is the transfer of pollen from the male part of the flower to the female part of the flower (the stigma) to allow fruit to set and seeds to develop. Seeds cause the fruit to develop properly.
If both the pollen and stigma are from the same flower or from another flower from the same variety, the process is called self-pollination. Fruit trees that set fruit as the result of self-pollination are called self-fruitful, whereas those relying on pollen from a different variety are called self-unfruitful. The latter needs two varieties near to each other for fruit set to occur. This is called cross-pollination.

Apples Apples generally need two varieties for good fruit set. This can be another apple variety or a crab apple that blooms with the edible crop.
Apricots Self-fruitful
Berries (all types) Self-fruitful
Cherries Sweet cherry is self-unfruitful and needs two varieties for good crop set. Sour cherry varieties are self-fruitful.
European plums Self-fruitful
Figs Self-fruitful
Japanese plums Self-unfruitful as a rule with the exception of Santa Rosa which will set fruit fairly well without cross-pollination.
Nectarines Self-fruitful
Peaches Self-fruitful with the exception of 'J.H. Hale' which has to be pollinated by another variety.
Pears These always need two varieties to ensure good fruit set.

SUPPORTING FRUIT TREES AND SHRUBS

Many of the fruits that we grow, such as free-standing apple or plum trees, require support only in the early stages, whereas other fruits, like the raspberry, need this throughout their lives. Supports benefit the plants in a number of different ways. They help in establishing strong roots and can prop up trained specimens such as cordons and espaliers. This helps to maintain healthy vigorous growth and increase fruit yields.



Above: *Apples can easily be grown in rows as cordons that are supported by a framework of stakes and wires.*

WALL AND FENCE FRUIT

The training of fruit on a wall or a fence is carried out to gain the maximum production of high-quality fruit in a limited space. As well as being ideal for a small garden, this can also look extremely decorative. Numerous training systems, based on the art of espalier which originated in France and Italy about 400 years ago, have been devised. The most useful training systems used in gardens today are the fan, espalier and cordon. Apples, pears and plums are all suited to this method of training, which is usually supported by a wall, fence or wire trellis. The plants are normally held to the wall or fence using wires which are held in place by vine eyes, positioned 60–90cm (2–3ft) apart. The wire is led through the holes in the vine eyes and secured at both ends. The wires should be no more than 30–45cm (12–18in) apart.

FREESTANDING WIREWORK

Raspberries, blackberries and other hybrid berries are all grown on a permanent framework. They are usually grown on a freestanding structure that supports the loose growth of the plants. To build such a structure, insert a post at least 60cm (24in) into the ground at the end of each row. Brace each end post with another post set at a 45-degree angle. Insert intermediate posts between the two end ones at a distance of every 2m (6½ft). They are set in at the same depth as the end posts, but no bracing posts are needed. Fix the wires on to the posts so that they run the length of the support. Place the first wire 60cm (24in) from the ground, pull tight and attach to the posts using staples or eye-bolts. The other wires are attached at 30cm (12in) intervals until they reach the top of the support. The final height depends on the height of the fruit.

INDIVIDUAL SUPPORT

When they are first planted, all free-standing trees require support to help them to establish a strong healthy root system. You can use a stake to support a fruit tree, ensuring that the stake is placed on the windward side of the tree. The stake is inserted before the tree is planted and is driven well into the ground. The general rule is to have a stake that is one-third the height of the tree showing above the ground. The tree is then tied to the stake using a tree tie. Do not use string or rope because this can damage the bark. A low stake such as this will allow the top part of the tree to move about freely and so help the tree to thicken and strengthen its trunk. For most fruit trees the stake should only be left in the ground for approximately one year and not for several years as is commonly practised.

STAKING A FRUIT BUSH



1 *Using a large mallet, drive a strong wooden post into the ground at the end of a row of the fruit bushes to a depth of about 60cm (2ft).*



2 *Fix another strainer post at a 45-degree angle in order to support the upright. Place this on the side the wire is to run and nail it firmly.*



3 *Fix the wires to one of the posts and then stretch these tightly along the row, stapling them at each post along the row as you go.*



4 *The fruit bushes can be fastened to or trained along these wires. Take care not to tie stems too tightly as this will damage them.*

PROTECTING FRUIT

There can be few more frustrating events in the kitchen-garden calendar than losing your fruit crop (or a fair portion of it) to birds. However, we have to remember that birds are a strong ally in the fight against pests in an organic garden and should be encouraged into fruit-growing areas when the bushes are not fruiting. Protection for the fruit crops will therefore need to take the form of moveable cloches or fruit cages where the netting can be removed after fruiting has taken place.



Above: *Cloches can be used to protect young strawberries from bad weather and also to keep pests at bay.*

FRUIT CAGES

This is perhaps the easiest way to protect tall fruit crops such as blackcurrants, raspberries and gooseberries because these plants can all be grown under the one structure. This makes it easy to maintain and harvest the fruit.

A permanent fruit-cage structure with removable netting is the ideal scenario because the netting can be put in place just before the crop ripens and then is taken down again after fruiting has occurred. This allows the birds to roam freely around the area at all other times, but without jeopardizing the crop at fruiting time. Alternatively, a series of small cages can be constructed over crops that ripen at different times, netting each of them individually as the fruit begins to ripen. This is a wildlife-friendly way of protecting the fruit, but it is also time-consuming.



Above: *A tunnel of wire netting is ideal for protecting ripening strawberries from pests such as birds.*

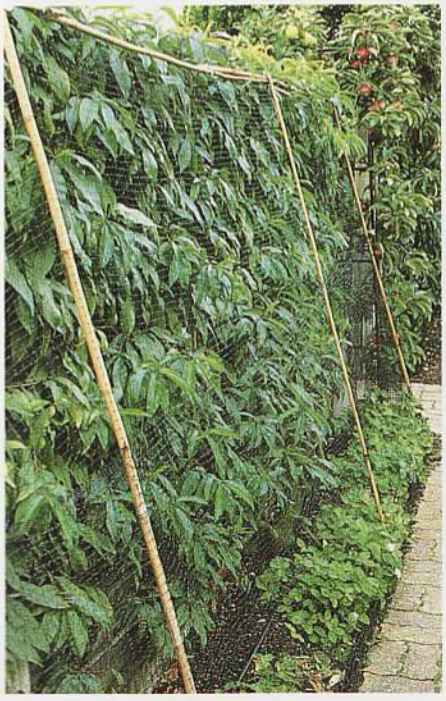
LOW-LEVEL PROTECTION

Smaller- or lower-growing crops, such as strawberries, can also benefit from a barrier to protect them from birds. This is easily achieved, as the structure does not need to be large, permanent or even particularly sturdy. One simple method is to form a low tunnel of chicken wire, supported on hoops that are bent into an inverted U-shape. For larger areas, a series of stakes hammered into the ground can be covered with netting to keep the birds at bay. Plants growing on wire trellises can be protected with netting draped over the stakes and top wires and weighted at the base with stones.

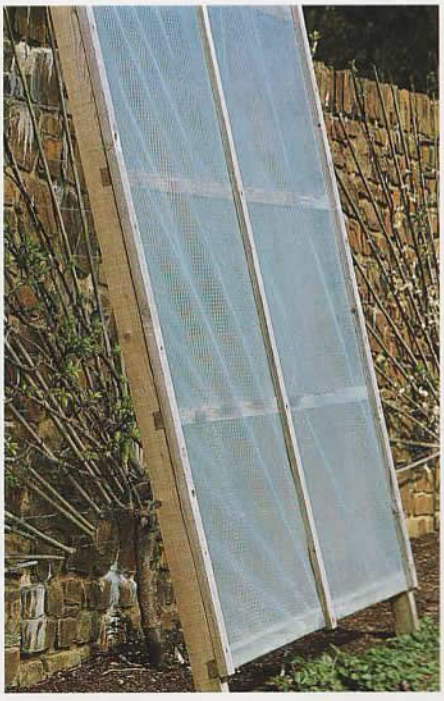
Larger bush fruit can be covered with netting and weighted down with stones. A little of the crop may be accessible to birds, but most will be protected.

PROTECTION WITHOUT BARRIERS

Most bird deterrents depend upon shocking the birds or mimicking something that they are naturally afraid of. Scarecrows are an age-old favourite. Other deterrents mimic the shape of hawks or make noises that will startle the birds. A relatively recent "innovation" has been to hang compact discs from wires stretched through the crop. Most of these deterrents tend to work very well at first until the birds get used to them. However, the only drawback is that when the birds get used to them, they resume their onslaught with a vengeance. The only way to overcome this is to keep changing the deterrents every few days.



Left: *Fruit trees growing against a wall can easily be protected with a cost-effective frame that is covered with netting.*



Right: *Fleece stretched over a frame can help protect the blossom of wall specimens from late frosts.*

PRUNING FRUIT TREES AND SHRUBS

The general purpose of pruning fruit trees is to regulate growth, increase crop yields and to improve fruit size and quality. The fruit trees also need to have all the dead, diseased and damaged wood removed as well as overcrowded areas thinned out. Pruning is also performed in order to establish a tree with a strong framework that is capable of supporting heavy crops without causing damage to the plant.



Above: *The careful pruning of trained specimens, such as this pear, will result in good blossom and improve fruit yields.*

WHEN TO PRUNE FRUIT TREES

If a fruit tree is pruned in spring, all the effort that the tree has put into bud production is wasted. The best time to prune is in winter when the plants are dormant and the sap has not yet started to rise. This applies to all fruit except for plums and cherries which are susceptible to silverleaf disease at this time and are best pruned in summer.

Summer pruning is also recommended if you wish to control vigorous growth in formally trained fruits such as fans, cordons and espaliers.

When pruning is underway, older fruit-bearing trees should be pruned first. Young, non-bearing apple trees and stone fruits can be pruned later to minimize the risk of winter injury.

BASIC PRUNING CUTS

Although there are different methods of pruning and training, the pruning cuts are the same. Always make the pruning cut just above a bud, ensuring that the cut is angled away from the bud. This will allow rainwater to drip down the other side of the stem and away from the bud, thus protecting the top of the cut from rotting.

Larger branches will need to be cut with a saw. If the branch is very heavy, you will need to remove the branch in three separate stages. Cut underneath the branch first, 20–25cm (8–10in) away from where the final cut will be. Make the second cut on the top of the branch just behind the first undercut. Follow this through until the weight of the branch makes the wood split and it falls off cleanly at the undercut. You will then need to make a third cut at the branch collar, cutting straight from the top to the bottom of the branch as there is no weight left to tear the bark.

BENEFITS OF PRUNING

Pruning fruit trees and bushes has many advantages, some of which are outlined below.

- Increased fruit yields.
- Can aid ripening of the fruit.
- Maintains healthy growth.
- Regulates growth.
- Improves fruit size and quality.
- Controls the spread of diseases.



Above: *Training can give rise to a variety of ornamental shapes. These pear trees have been trained into a cylindrical shape.*

PRUNING LARGE BRANCHES



1 *Make a cut about 20–25cm (8–10in) out from where the final cut will be on the underside of the branch. Cut about a third of the way into the branch.*



2 *Make a cut about 10cm (4in) nearer the position of the final cut, cutting until the branch snaps. The initial undercut prevents the wood splitting or bark from stripping.*



3 *Position the saw for the last cut to avoid damaging the swollen area at the base of the branch. The cut will heal in a couple of seasons. No wound painting is necessary.*

SUCCESSFUL FRUIT TREE AND SHRUB PRUNING

Pruning fruit trees is a very complex subject and, like so many areas of organic gardening, is the subject of opinion and hot debate. Despite this it is possible to apply certain guiding principles that can enable you to prune your fruit trees and bushes successfully.

1 **Remove root suckers arising at the base of the tree**
These compete with the upper growth for water and essential nutrients and their dense habit can harbour pests.

2 **Always cut out dead, dying, damaged or diseased limbs first**
Helps to maintain the plant's health and enables you to see precisely what needs doing next.

3 **Remove low, drooping limbs**
These will not bear fruit and will often be heavily shaded by growth above. They are an unproductive drain on the tree.

4 **Remove upright growth or outward growth in the case of wall-trained bushes**
Upright growth will produce a flush of growth at the end and will not fruit well. Branches growing away from the wall will shade the fruit behind causing poor ripening.

5 **Remove crossing or dense parallel growth**
Crossing growth will rub and can cause bark damage that will allow disease entry. Dense growth will also shade the developing fruits. This will slow and limit the ripening of the fruit.

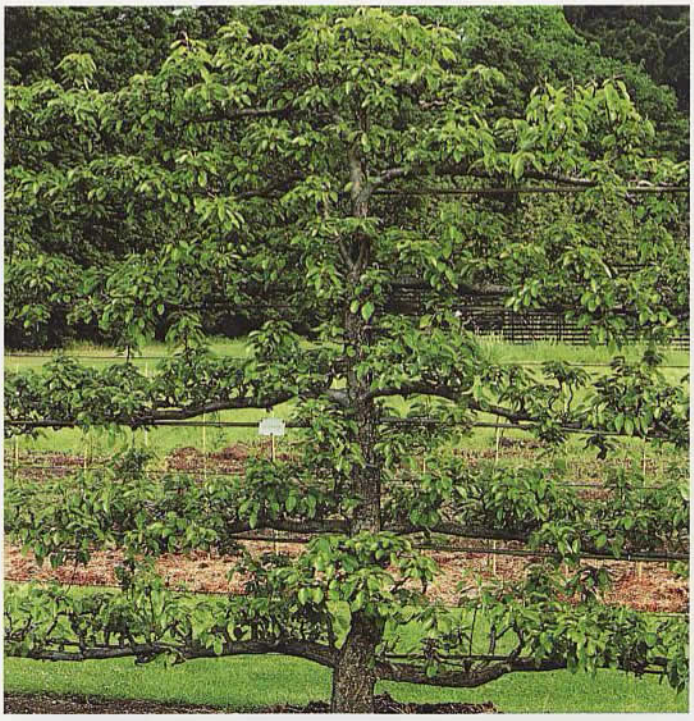
6 **Freestanding trees should have upper limbs cut back further than lower limbs**
This will result in the development of a conical shape that will allow light penetration all the way down the side. Fruit will ripen more evenly.

7 **Remove water sprouts as they develop**
Water sprouts can quickly develop and cover the developing fruits, causing poor ripening and harvesting difficulties. They can be easily removed by hand. This is best done early in the season when the growth is soft and is therefore easily removed. Carry out regular inspections throughout the season to control the water sprouts.

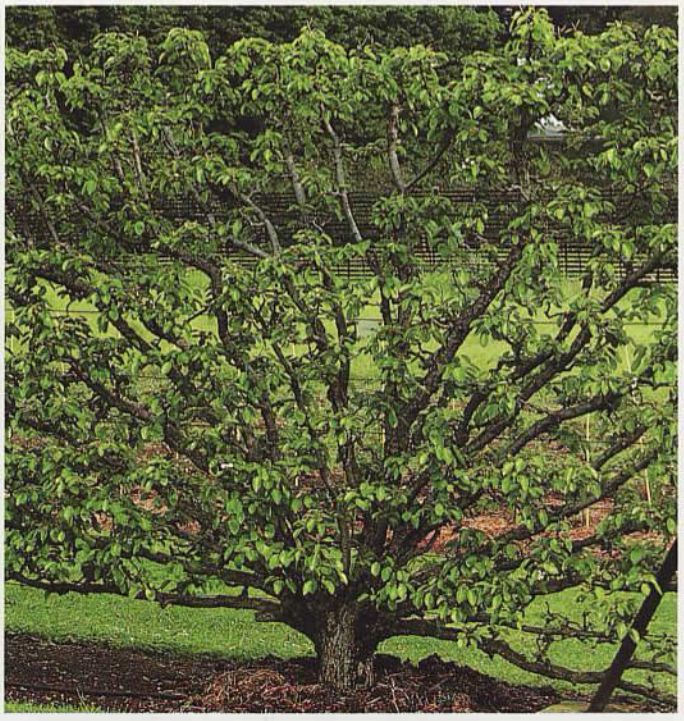
8 **Once the larger cuts have been made, thin out the smaller branches**
Removing thick branches first allows you to see what remains to be done and also makes it easier to get to the remaining pruning work. Removing older wood encourages young growth to fill the gap. Remember to stand back and view what you have pruned as you go along.

9 **Always make clean cuts above a leaf bud or close to the stem**
Pruning cuts that are not performed cleanly or that leave a long stub will damage the plant tissue and encourage the entry of pests and diseases.

10 **Avoid feeding with nitrogen for a season before and following heavy pruning**
Both pruning and high nitrogen fertilizers promote the development of rapid growth flushes that can result in the poor development of the crop.



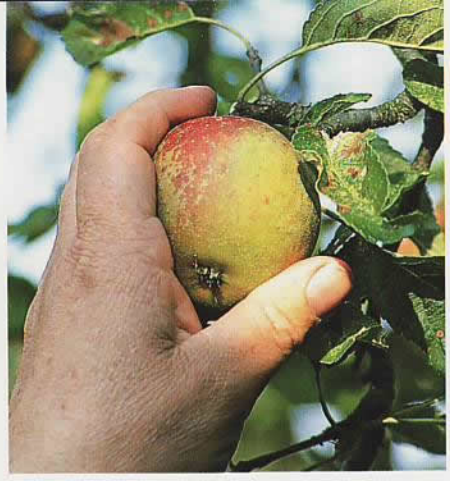
Above: *This well-established pear tree has been trained into an espalier on wire supports. Many fruit trees can be grown and supported in this way.*



Above: *This pear tree has been grown as a fan. Fans are an ideal way to train many species of fruit tree and are well suited for growing against a wall.*

HARVESTING AND STORING FRUIT

When harvesting your fruits, you will find that there is only so much you can eat fresh or give away. There is always surplus fruit left over and you are faced with the question of what to do with it. Leaving some on the plant to help feed the wildlife in your organic garden is a good idea, but storing the rest of the excess fruit using a variety of methods will ensure that you can eat your home-grown produce over a longer period of time.



Above: *An apple is ready to be picked if it can be removed from the tree with only a single twist of the fruit.*

HARVESTING

The key to successfully storing fruit begins well before harvesting commences. Your first objective should be to grow fruit that is as healthy as possible because it will be the best for storage. Harvesting immature crops or attempting to save those that are in poor condition – due perhaps to a lack of water or nutrients or to pest and disease damage – can lead to many storage losses.

There are several ways that fruit can be stored and the condition of the picked crop will usually be the deciding factor as to which of these you should use. Top fruit such as apples and pears can often be stored fresh through most of the winter, whereas stone fruits and berries, such as peaches, strawberries and raspberries, must be quickly consumed, turned into a preserve or frozen.

Careful handling, both during and following harvesting, is essential because, from the moment they are harvested (and in many cases well before), crops have no means of repairing any physical damage that they may suffer. Even firm, strong-looking fruit such as apples can easily be bruised, although the damage may well not show up immediately.

As well as good handling, a careful selection of the fruits during harvesting is essential for successful storage. You should inspect the picked fruits and select only those of the best quality for fresh storage. Reject any that have a broken skin or show any sign of pest or disease damage. Do not throw them on the compost heap yet, however, because damaged fruit may well be useful for making preserves such as jellies and jams or for freezing.

It is also a good idea to leave a small percentage of mature fruit on the plants when you are harvesting to help feed the wildlife in your organic garden.

STORING

In general, the storage area for fruit must be frost-free, safe from pests, rainproof and ideally kept at a constant temperature.

STORING FRUIT

To store surplus fruit and avoid the risk of rotting, make sure that you use the appropriate method.

Apples, pears and quinces
Store in a cool place for up to 12 months, depending on the variety.
All other fruit Eat immediately or freeze. Alternatively, preserve fruit by bottling or making into jam. Fruit can be kept for up to 12 months, depending on the method of preservation that has been used.

The long-term storage of any fruit calls for cool conditions with adequate ventilation. If you have space, consider having a separate refrigerator specifically for fruit storage, or choose an area with a low temperature that does not go below freezing. A garden shed or garage can be ideal, in many cases, but even these





Far left: *Pick soft fruits, such as strawberries, raspberries and gooseberries, carefully to avoid bruising the fruit.*

Left: *Pears can last for up to 12 months, depending upon the variety. Lay them in a recycled box, ensuring that the fruits do not touch and air can circulate around the fruit.*



Above: *Fruit trays, recycled from supermarkets, make ideal storage boxes for surplus fruit. The trays should be kept in a cool dry place such as a garage or shed.*



Above: *Soft fruit is best placed in small individual containers as it is picked to prevent it being squashed and spoiling. Store in a refrigerator or other cool place.*

spaces may need extra insulation if winter weather conditions become severe. Some houses have a basement, cellar or unheated room that may be ideally suited for the task. Attics are not recommended for fruit storage because of their wide temperature fluctuations and variable humidity.

It is worthwhile trying out a variety of different storage methods. This can be done by splitting the crop up and then trying out different locations in your home. You will soon find which are the best places to store fruit, and what areas are best for storing a particular kind of fruit.

Ensure that you check the stored fruit regularly, at least weekly, removing any that show signs of decay. Remember the old adage that "one bad apple spoils the whole barrel"? This can be true for your crop too unless you prevent rots from spreading. The unblemished parts can often still be used for eating or cooking. If lots of fruits begin to rot simultaneously, it could be that the storage conditions are not suitable, the crop has reached its maximum "shelf-life" or the fruit was not of sufficiently good quality to start with.

FREEZING AND PRESERVING

Freezing is an excellent way of storing all the surplus fruit that has been produced in your garden. Unfortunately, fruit tends to lose its firmness once it has been frozen, although the taste will remain more or less the same. Raspberries, for example, are best used for making pies or flans after they have been frozen and will be of very poor quality if they are eaten raw. Most fruits can be frozen after they have been stewed or puréed; this is true of fruits such as apples and plums.

Fruits like strawberries and blackcurrants that are not suited to long-term storage can be made into jams, pickles and chutneys. You can find recipes for these in good cookbooks.



Above: *One of the simplest ways of preserving fruit is to freeze it, although once frozen most fruits are only good for cooking.*



Above: *Adding a favourite fruit such as these cranberries to good wine vinegar can produce interesting flavours.*



Right: *Bottling fruit in alcohol is an ideal way to preserve soft fruits such as peaches, nectarines and apricots.*

CALENDAR OF CARE

WINTER

THE ORNAMENTAL GARDEN

EARLY WINTER
- Continue cultivating the soil, if not already done, when the ground is not wet.
- Continue planting and transplanting on mild days.
- Press plants that have been lifted by frost back into the ground.
- Plant herbaceous perennials for next year.
- Last chance to plant roses.
- Move greenhouse plants to the house as they come into flower.
- Start pruning deciduous shrubs and trees during spells of fine, frost-free weather.

MID-WINTER
- Finish digging and trenching and fork over borders.
- Order seeds for coming season.
- Protect autumn sown annuals from frost.
- Prepare ground that is to be planted out with bedding plants with manure.
- Tidy up climbing plants and remove any dead wood.
- Firm down herbaceous plants that have been lifted by the frost and protect the new shoots of young tender plants.
- Plant evergreen and deciduous shrubs.
- Trim deciduous hedges and shrubs to start bringing them into shape.
- Take hardwood cuttings and layers of deciduous shrubs.
- Sow annuals in gentle heat.
- Take cuttings of tender shrubs and start under gentle heat.

LATE WINTER
- Tidy up unused ground and apply a top-dressing of manure or leaf mould.
- Protect bulbs from mice, snails and birds.
- Prune roses planted this month.
- Start to train and trim climbers.
- Divide herbaceous plants.
- Sow annuals in gentle heat.
- Transplant autumn sown annuals.
- Plant edgings such as box (*Buxus*) hedging, pinks (*Dianthus*) or thrift (*Armeria*).

THE WILDLIFE GARDEN

EARLY WINTER
- Try to maintain a fresh supply of clean unfrozen water for wildlife.
- To keep some open water on ponds, put in a floating ball or anchored block of polystyrene, preferably painted black, to absorb the warmth of the sun.
- Leave tidying the garden until late winter to shelter overwintering insects.
- Leave log and leaf piles completely undisturbed until spring.
- Feed resident birds with high energy supplements such as fat balls.
- Order seed now for early sowings of perennials and annuals.

MID-WINTER
- Put plenty of food in the garden for resident birds.
- Hang nesting boxes ready for breeding birds.
- Build dry-stone walls with gaps to provide shelter for reptiles and amphibians.
- Look out for wildlife tracks in snow and position cat deterrents at entry points.
- Provide food for non-hibernating mammals if present.
- Keep a record of wildlife to help you target future feeding and habitat creation.

LATE WINTER
- Continue feeding resident birds.
- Put up a range of different nesting boxes and make each box as inconspicuous as possible. Reposition any nesting boxes that were unused last year.
- Stretch wires or heavy-duty cord at least 10cm (4in) proud of walls and fences and train climbing plants to form a screen with a gap behind it for nesting birds.
- Trim one side of hedges to encourage dense new growth as nesting cover, but leave some flowering stems on spring-blossoming species such as hawthorn (*Crataegus*) for nectar.
- Protect bulbs from mice, snails and birds.

SPRING

EARLY SPRING
- Feed lawns where the grass is thin and seed areas where the grass has been completely worn away.
- Prepare borders ready for biennials and perennials next month.
- Remove leaves and other debris from borders and fork over.
- Tidy up spring bedding plants.
- Sow hardy annuals when the weather is dry and mild.
- Start pruning roses.
- Trim box edging and damaged evergreens.
- Prick out annuals started last month.
- Start to harden off early seedlings ready for bedding out.
- Look for pests and diseases and deal with them as they occur.

MID-SPRING
- Hoe off weeds.
- Watch for signs of frost and protect young shoots.
- Watch out for pests and diseases.
- Give the lawn its first cut and tidy its edges.
- Stake and tie any plants that need it.
- Sow hardy annuals.
- Propagate hardy perennials, including water plants.
- Finish winter pruning and prune late winter/early spring flowering shrubs before they commence growth.
- Continue hardening off summer bedding and pinch out the tops.
- Trim and tidy up all climbers before they start into growth.
- Sow half-hardy annuals and take cuttings.
- Give box hedges their first clipping.

LATE SPRING
- Hoe off weeds.
- Finish off digging and rotavating to prepare the beds for planting.
- Water newly planted plants in dry weather.
- Keep an eye open for pests and diseases.
- Tidy bulb beds after the foliage has died down.
- Tie in sweet peas (*Lathyrus odoratus*) and check the support of other climbers.
- Finish sowing hardy annuals and plant out those raised under glass. Thin outdoor sowings and transplant where necessary.
- Plant half-hardy bedding plants when the danger of frost is over.
- Divide spring-flowering plants, like primroses (*Primula vulgaris*), for next season.
- Shrubs should have old wood removed and thinned out.
- Continue taking cuttings.

EARLY SPRING
- Put plenty of food in the garden for resident birds.
- Create a wildlife pond ready to plant up next month.
- Supplement the diet of resident early nesting birds with mealworms and waxworms.
- Emerging hedgehogs will benefit from a feed of cat food near their nesting sites.
- Hang nesting boxes for solitary bees.

MID-SPRING
- Plant new garden ponds and replace dead plants in established ponds.
- Sow seeds of hardy annuals in a sunny spot to attract insects during the summer until late autumn. Mix them up with salad crops to act as helpful companion plants.
- Install a "cage" of large-gauge chicken wire around nesting sites to allow nesting birds in but keep out magpies, grey squirrels and other nest-robbing species.
- Keep one or two nest boxes sealed so as to prevent the entry of resident birds until migrant bird species arrive.
- Continue feeding garden birds.
- Continue feeding hedgehogs until natural prey increases in numbers.
- Propagate hardy perennials, not forgetting water plants.

LATE SPRING
- Plant pot-grown seedlings of spring-flowering wild flowers in an area of lawn where you can leave the grass uncut until mid-summer.
- Sow the seeds of wild flowers thinly on the surface of gritty potting mix.
- Divide spring-flowering plants, such as primroses (*Primula vulgaris*) and cowslips (*P. veris*), for next season.
- Continue feeding garden birds.
- Put up bat boxes to encourage bats to roost in the summer.

SUMMER

EARLY SUMMER
- Mulch round plants and shrubs that need to be kept moist.
- Keep an eye out for pests, and keep weeds under control.
- Cut down and tidy perennials as they finish flowering.
- Feed roses and sweet peas (*Lathyrus odoratus*) with manure or compost tea.
- Sow biennials and perennials.
- Plant out plants raised under glass, dividing and planting out those that have finished flowering in other areas.
- Thin out seedlings and stake carnations (*Dianthus*), dahlias and sweet peas.
- Sow hardy annuals for autumn planting.
- Spray the foliage of new trees with water in hot or dry weather.
- Tidy up rhododendrons and other plants by removing seedheads, unless leaving them for decoration and food for the birds.

MID-SUMMER
- Continue to hoe weeds and water newly planted specimens.
- Stake and tie plants.
- Layer or take cuttings from carnations.
- Pinch out the tops of chrysanthemums to prevent straggly plants.
- Water and feed sweet peas with a compost or manure tea.
- Sow perennial and biennial seeds for next year.
- Continue taking cuttings.
- Sow seeds for overwintering in the greenhouse.
- Pot plants that need repotting.
- Cut away dead and unwanted foliage on vigorous shrubs.
- Trim deciduous hedges.
- Propagate shrubs by cuttings or layering.

LATE SUMMER
- Continue watering, mulching and hoeing.
- Remove all dead flowers, stalks and leaves.
- Train and tie clematis, honeysuckle (*Lonicera*) and wisteria.
- Trim plants such as lavender and penstemons after flowering.
- Water and feed sweet peas with a compost or manure tea.
- Take cuttings of old-fashioned roses.
- Thin perennial seedlings.
- Divide and replant spring-flowering perennials.
- Take cuttings of fuchsias, pelargoniums, heliotrope, hydrangeas and all half-hardy plants.
- Remove dead flowers and stalks from summer-flowering shrubs, unless they are berry producing.

AUTUMN

EARLY AUTUMN
- Hoe off any late weeds.
- Start tidying up for winter, but leave seedheads for birds.
- Put unwanted debris on the compost heap.
- Collect seeds and label for sowing next year.
- Start digging, manuring and rotavating heavy soils.
- Repair patches on lawns.
- Start collecting fallen leaves to make leaf mould.
- Tie and stake dahlias and tall shrubs.
- Cut back and support climbing plants.
- Sow spring-flowering seeds, starting with hardy annuals.
- Plant spring bulbs.
- Plant or transplant evergreen shrubs, conifers and herbaceous plants.

MID-AUTUMN
- Collect fallen leaves to make leaf mould.
- Prepare areas for planting.
- Repair and lay new lawns, repair paths and walkways.
- Make final plantings of bulbs.
- Collect seeds of late-flowering plants.
- Lift and store half-hardy bulbs, corms and tubers.
- Lift, divide and replant herbaceous plants.
- Sow early sweet peas (*Lathyrus odoratus*).
- Start planting out spring bedding.
- If moving deciduous shrubs, do so to encourage new root growth.
- Take cuttings until the cold weather sets in.

LATE AUTUMN
- Continue digging heavy and medium soils, leaving the light soils for spring.
- Spread surplus manure around flowerbeds if leaf mould is not available.
- Fork over herbaceous borders, leaving dead foliage until spring.
- Take cuttings of plants that may need replacing.
- Make final plantings of spring bedding.
- Take rose prunings from choice plants and push into the ground in a sheltered position where they may strike and give you more plants.
- Put bulbs for forcing under glass in pots.
- Plant flowering shrubs and trees for next season.

EARLY SUMMER
- Plant tobacco plants (*Nicotiana*) to guarantee interesting night-flying moths and the bats that feed on them.
- Check fruit nets each day to ensure no birds are trapped inside.
- Choose bedding plants with simple flowers and keep a note of which the bees and butterflies prefer.
- Leave seedheads on spring-flowering shrubs such as rhododendrons as food for birds.
- Continue feeding garden birds, with seed and waxworms or mealworms, especially if there is a dry spell.

MID-SUMMER
- Watch for night-flying moths on tobacco plants, late flowers on the honeysuckle, and tall yellow evening primroses.
- Continue to check fruit nets each day for birds.
- Take special care when turning compost heaps as grass snakes may be nesting and hedgehogs often sleep in them.
- Make log piles for wood feeding insects such as stag beetles.
- Lightly trim deciduous hedges if birds have finished nesting to encourage dense cover in the winter.
- Continue feeding garden birds, especially if there is a dry spell.

LATE SUMMER
- Plant early spring bulbs now for nectar next year, especially for overwintering insects.
- Lightly trim nectar-rich plants such as lavender (*Lavandula*) and nepeta after flowering to encourage new growth.
- Dead-head herbaceous plants to encourage fresh flowers that give an extra boost to pollinators in the early autumn.
- Leave seedheads and berries on summer-flowering shrubs for birds.
- Continue feeding garden birds.

EARLY AUTUMN
- Let one or two old vegetables flower, such as leeks, carrots and almost any member of the cabbage family, to boost nectar supplies for autumn insects.
- Look now to see if there is a shortage of nectar and redesign flower borders accordingly. Remember to select single-flowered plants where possible.
- Build new log piles, rock piles and brush piles ready for overwintering insects, reptiles, amphibians and mammals.
- Place nest boxes outside for overwintering mammals such as hedgehogs.
- Continue planting spring bulbs for early nectar next year.
- Plant evergreens to provide dense winter cover for birds and mammals.
- Continue feeding garden birds.

MID-AUTUMN
- Start a new compost heap.
- Let hedge prunings, raspberry canes and other woody waste accumulate and leave them to become a hibernation heap for hedgehogs.
- Weed among and divide most pond plants before they die back. This removes excess nutrients from the pond and minimizes next summer's algal blooms.
- Pile weeds and thinnings from ponds at the side until the following day to give trapped pond dwellers time to escape.
- Place nest boxes outside for overwintering mammals such as hedgehogs.
- Continue planting spring bulbs for early nectar next year.
- Begin putting out high energy supplements such as fat balls for birds.

LATE AUTUMN
- Plant hedgerows using native shrubs and trees.
- Plant late-flowering nectar plants like English ivy (*Hedera helix*) against a boundary that catches autumn sun.
- Put in late bulbs at least 7.5cm (3in) deep and bury chicken wire just below the surface to avoid them being eaten by squirrels.
- Feed resident birds with high energy supplements such as fat balls.

WINTER

THE KITCHEN GARDEN

VEGETABLES

EARLY WINTER
- Hoe between crops on fine days.
- Examine stored onions and potatoes for any sign of disease and discard second-class seed. Any potatoes that are sprouting should be placed apart in dry trays.
- Protect more tender plants with leaves or cloches.
- Begin forcing rhubarb and seakale under a light-proof cover.
- Order seed catalogues and plan the new season's crops.

MID-WINTER
- Tidy up and put vegetable waste on the compost heap.
- Hoe between growing crops when dry.
- Sow broad (fava) beans and peas in warm sheltered positions.
- Sow early vegetables under glass or cloches.
- Start potatoes in a frost-free shed.
- Plant rhubarb in well-manured beds.

LATE WINTER
- Hoe weeds when the weather allows.
- Clear old beds ready for new season.
- Cut pea and bean sticks.
- Sow early vegetables under glass or cloches.
- Plant artichokes, garlic, shallots, lettuce (winter), potatoes (early), rhubarb and seakale.
- Plants overwintering under cloches should be hardened off and only protected when the weather is frosty.

FRUIT

EARLY WINTER
- Finish pruning fruit trees and bushes on frost-free days. Large standard trees will need pruning every second or third year.
- Firm newly planted trees where the frost has been at work.
- Do not plant any more trees until the spring; just prepare the ground.
- Currants and gooseberries should be pruned if not already done.
- Prune outdoor vines.
- Remove unwanted suckers from raspberry stools but do not prune until early spring.

MID-WINTER
- Start pruning hardier trees such as apples. Do not prune apricots, cherries, figs, nectarines and peaches.
- Prepare grafting material.
- Plant container-grown trees and cover soil with well-rotted manure.

LATE WINTER
- Prune damsons, pears, plums and quince.
- Spread manure around fruit trees and dig it in.
- Prepare new strawberry beds.
- Fertilize by hand the blossom of fruit trees grown under glass.

HERBS

EARLY WINTER
- Prepare ground for planting when conditions allow.
- Protect tender herbs under cloches.
- Continue to remove dead stems from herbaceous types.

MID-WINTER
- Prepare ground ready for planting.
- Force early growth under cloches.
- Make early sowings under glass.

LATE WINTER
- Remove dead stems from herbaceous types.
- Continue forcing under cloches.
- Continue sowing under glass.

SPRING

EARLY SPRING
- Hoe weeds when the weather allows.
- Prepare seedbeds.
- Protect early crops from birds.
- Begin sowing in sheltered places in the open.
- Sow early vegetables under glass or cloches.
- Plant out early crops raised under glass and early potatoes.
- Plant early broad (fava) beans out in the garden under glass.

MID-SPRING
- Hoe weeds regularly.
- Prepare beds for planting out.
- Feed cabbages with high-nitrogen fertilizer such as chicken manure.
- Potatoes need the soil drawn over their leaves to protect them from frost.
- Begin sowing remaining summer crops outdoors.
- Continue sowing more tender crops under glass.

LATE SPRING
- Hoe weeds regularly.
- Cut asparagus when shoots reach 15cm (6in).
- Maintain the succession of seed sowing to give salad throughout the summer season.
- Continue planting out summer crops.
- Sow late crops such as broccoli and plant out winter crops previously sown under cover.
- Last chance to plant late potatoes.
- Plant out cucumbers, pumpkins and melons in beds previously used for protected early crops.

EARLY SPRING
- Protect blossom with fleece on cold nights.
- Last chance to plant container-grown fruit bushes.
- Graft apples, cherries, pears and plums that were prepared in mid-winter.
- Finish pruning fruit trees and bushes.

MID-SPRING
- Continue protecting blossom.
- Wall trees will need moisture from now on.
- Watch for pests and diseases.
- Grapes will require thinning in order to swell their size.

LATE SPRING
- All fruit will benefit from a mulch.
- Apricots, peaches and Morello cherries should have fruiting spurs shortened back to three to four leaves.
- Limit raspberry suckers to around four to six to each stool.
- Put straw around strawberries to protect the fruits from the ground.

EARLY SPRING
- Continue sowing under glass.
- Plant out hardy herbs once hardened off.
- Prune shrubby types.
- Lift and divide herbaceous types until late spring.

MID-SPRING
- Continue sowing under glass.
- Continue planting out.
- Take basal cuttings.

LATE SPRING
- Sow herbs like parsley (*Petroselinum crispum*) and chervil (*Anthriscus cerefolium*) for winter use.
- Continue sowing under glass and planting out.

SUMMER

EARLY SUMMER
- Hoe weeds regularly throughout summer.
- Water all salad crops regularly.
- Feed heavy feeders like cauliflowers with liquid manure or compost tea.
- Keep picking peas to stimulate flowering.
- Harvest early potatoes and replace with winter turnips or late celery.
- Support runner beans.
- Sow the last of the outdoor salad crops and continue sowing seed of late or winter crops.
- Thin out seedlings.
- Plant late-season crops raised under cover.

MID-SUMMER
- Water all salad crops regularly.
- Remove debris, following harvest, to the compost heap until late summer.
- Potatoes and other crops may need earthing-up.
- Pinch out and stop tomatoes and marrows.
- Maintain the succession of seed sowing for late or winter crops.
- Thin out the beetroot crop so that the roots can form properly.
- Plant late-season crops raised under cover.

LATE SUMMER
- Water all crops regularly.
- Remove debris, following harvest, to the compost heap.
- Harvest seed from French (green) beans and onions.
- Garlic and onions can be harvested this month and then ripened.
- Potatoes for next year's seed should be dug up and dried in the sun.
- Maintain the succession of seed sowing for late or winter crops.

AUTUMN

EARLY AUTUMN
- Hoe weeds regularly throughout autumn.
- Water all crops regularly.
- Harvest onions and bend down the necks of the remainder to prevent seeding.
- Continue to lift potatoes.
- Expose the fruit of outdoor tomatoes to the sun by removing the covering leaves.
- Maintain the succession of seed sowing for late or winter crops.
- Plant late season crops raised under cover.

MID-AUTUMN
- After beans and peas have been harvested, turn the soil over and leave it fallow over the winter.
- Lift root vegetables when their tops fade.
- Cut down asparagus foliage when mature.
- Onions and turnip beds should be thinned.
- Clear the last of the potatoes and store them.
- Earth up celery and leeks.
- Plant out late-season crops and protect tender types such as cauliflower.

LATE AUTUMN
- Get the soil ready for spring sowing.
- Protect crowns of tender crops with a mulch of leaves.
- Lift the last of the beetroot and carrots.
- Earth up celery and leeks if not already done.
- Spinach will continue to crop as it is thinned.
- Dry off the late potatoes for seed stock next year.
- Continue to plant out late-season crops and protect tender types such as cauliflower.

EARLY SUMMER
- Continue mulching trees and bushes to conserve moisture.
- Cut back untidy vigorous growth.
- Over-laden trees may need support. Aphids will appear, so take appropriate action.
- Throw nets over fruiting trees and shrubs to prevent the birds getting the fruit first.
- Peaches and apricots may need some thinning.
- Strawberries should have regular watering.

MID-SUMMER
- Thin trees and remove unnecessary growth.
- Hoe round the roots of fruit trees and water them.
- Fruit trees may be budded when the weather is moist.
- Espalier and dwarf fruit trees will need training and protection from birds.
- Strawberries and loganberries should be layered and clipped to the soil to secure their position.

LATE SUMMER
- Protect fruit on walls from wasps and birds as it ripens.
- Pruning can be started and trees budded.
- Apples, pears and plums may need the fruit thinning out if the crop is heavy.
- Cut down the old canes of loganberries and raspberries after harvesting.
- Cut off unwanted runners from strawberries and remove the old straw from round the crowns.

EARLY AUTUMN
- Wall fruit that has ripened will need protecting.
- Fruit trees may be budded and light pruning continued.
- Early varieties of apples and pears that do not keep well should be gathered.
- Prune currants and gooseberries to keep them in shape. Raspberry canes that have fruited should be removed to make room for the new growth.
- Strawberries should have unwanted runners removed to give space to the main plants.

MID-AUTUMN
- Look though the nursery catalogues and order fruit stock, then prepare the ground and remove stock to be replaced.
- Move any trees or bushes that are in the wrong place.
- Apples and pears can now be gathered.
- Apricots, cherries, currants and gooseberries should be pruned and the cuttings burnt.
- Loganberries and raspberries should be planted now.

LATE AUTUMN
- This is the time to plant fruit trees in well-prepared ground.
- Begin winter pruning of fruit trees.
- Plant currants and gooseberries.
- Figs will need thinning.
- Spread manure between rows of new strawberry plants.

EARLY SUMMER
- Continue sowing under glass.
- Continue planting out until late summer.
- Harvest herbs for storing before they flower.
- Plant out tender herbs.
- Dead-head unless seed is required until late summer.
- Cut back herbaceous types to stimulate growth until late summer.

MID-SUMMER
- Cut mint (*Mentha*) and other sweet herbs for drying.
- Pull out parsley (*Petroselinum crispum*) unless it is being kept for seed.
- Propagate sage (*Salvia*) or savory (*Satureja*) from cuttings or division.

LATE SUMMER
- Harvest herbs as required.

EARLY AUTUMN
- Harvest seed as it ripens.
- Harvest leaves and stems as required.
- Cut back herbaceous types to stimulate new growth.

MID-AUTUMN
- Harvest seed as it ripens.
- Tidy away dead material.
- Protect tender herbs.
- Plant shrubby and herbaceous types until late autumn.
- Move tender container herbs under some protection.
- Divide herbaceous herbs until late autumn.

LATE AUTUMN
- Prepare ground for planting when conditions allow.

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DIY PROJECTS *for the*

Self-Sufficient Homeowner



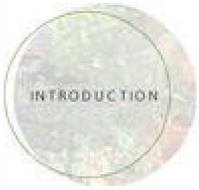


25 WAYS TO BUILD A SELF-RELIANT LIFESTYLE





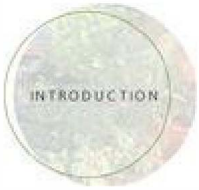



INTRODUCTION

DIY PROJECTS
for the
Self-Sufficient Homeowner

25 WAYS TO BUILD A SELF-RELIANT LIFESTYLE




INTRODUCTION

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Introduction

DIY PROJECTS

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Declare Your Independence

The world seems to be growing in complexity every day. While much of today's new technology makes legitimate improvements in our lives, this new electronic age has created something of a backlash. Each upgraded cellphone generation and ever-spreading factory farm distances us just a little bit farther from the days when all you needed to conquer the world was a tillable acre and a mule. The projects in this book are designed to help you close that widening gap—if only just a bit.

















Self-Sufficiency vs. Green

People who are interested in adopting a more self-sufficient lifestyle almost certainly subscribe to today's Green principles and to an approach to living based on stewardship. It is worth noting, however, that the projects described in this book were chosen because they result in a product, usually a consumable, that contributes directly to the pool of things you and your family need in order to live—and live well.

The decisions we make every day—even down to which grain was used to make the flour in your morning toast—are part of a chain of thousands of other decisions that, taken together, have a profound effect on the resources of our planet and the health and prosperity of our families. The urge to take back some control of our own lives and futures has never been stronger.

The good news is: You can. Whether you live in a bustling city, sprawling suburban development, or rural estate, you can achieve greater everyday self-sufficiency with relatively little effort. As self-sufficiency expert John Seymour wrote, "You do not need five acres and a degree in horticulture to become self-sufficient ... self-sufficiency is about taking control and becoming an effective producer of whatever your resources allow."

DIY Projects for the Self-Sufficient Homeowner provides you with around two dozen ways to help you maximize your resources and participate in the march toward greater self-reliance. Whether you own a small balcony downtown or a couple of acres in the suburbs, you can grow much more of your own food than you ever expected—as long as you have the right tools, such as raised garden beds, compost bins, container gardens, or even a small greenhouse. Whether you have an expansive estate or a small

backyard, you can raise animals—this book will show you how to build a chicken coop, a beehive, and animal-friendly fencing. It contains many more projects related to the production and storage of food from your own homestead.



Solar panels that collect and heat air to warm cold spaces in your home are mechanisms you can build yourself and duct in to your home's existing ductwork. Learn how on page 147.

But raising your own food is not the only way to increase your self-reliance. With new DIY-friendly technology, generating your own clean energy is easier than ever. Here, you'll see exactly how to build a solar panel, install solar energy systems, and understand alternative energy sources.

The key to your self-sufficiency is to focus first on a few doable projects that fit into your lifestyle without a lot of adjustments. Most modern homeowners will not be able to maintain a fully self-sufficient home without quitting their day job, and that shouldn't necessarily be the goal for everyone. All homeowners can, however, take steps toward greater self-reliance, and partake in the satisfaction that comes from providing for your family's needs through your own effort. So get started: The time has never been better to declare your independence.

The Self-Sufficient Lifestyle

Self-sufficient living is a highly complementary practice—once you begin, you'll find that many parts of your home are connected, and that multiple systems of self-sufficiency contribute to one another, often corresponding with the natural cycles of the earth. Because of this interconnectedness, many of the projects in this book will naturally lead you to more and more projects that will help you maximize your self-sufficiency work.



Building a greenhouse is a great way for gardeners to jump-start the growing season, or to introduce new, sensitive plants to your garden. See page 59.

For example, if you start a garden, the fruits and vegetables you grow will provide waste that will transform into the compost that will nurture next year's bounty. Setting up a rainwater collection system not only reduces your reliance on public utilities, the fresh, soft water will help your plants grow healthy. The hens you are raising for their eggs control garden pests and provide free fertilizer. At the end of the growing season, you'll likely be overwhelmed with vegetables, and will need to find a means to store and preserve them—perhaps a basement root cellar could be a good option. And, by growing organic vegetables nurtured by compost and animal manure, you create a pesticide-free habitat for honeybees to prosper, while they, in turn, pollinate the plant life.

That said, you do not need to take on all the projects in this book at once. Start with the projects that naturally supplement the efforts your family is already making toward self-sufficiency. If you already recycle, a natural next step is to build compost bins and begin to make compost with food and paper waste as well. If you already maintain a beautiful flower garden, why not build a home for the honeybees that are already frequent visitors, allowing you to collect the honey they produce? If you need to connect electricity to an outbuilding or shed that is not currently grid-connected, why not install solar panels instead of wiring the building into the grid? If you already garden, why not build a greenhouse?

For the newcomer, the projects on the following pages provide multiple opportunities to create a more self-reliant lifestyle. For the experienced self-sufficient homeowner, the step-by-step projects included here will provide you with the means to expand and streamline your efforts.

Efficiency, Conservation & Recycling

If increased self-sufficiency is your goal, paying attention to the efficiency with which you use your resources is common sense. For example, if your goal is to use solar-heated air to heat all or part of your home, it makes sense that you want every bit of the heat your solar panels produce to contribute to the temperature of the room, instead of being lost through drafty windows or poorly insulated walls. Investing in energy-efficient windows and doors and properly insulating your home is a very important step in the implementation of an alternate or supplementary heating system.

If one of the goals of your self-sufficient lifestyle is to decrease your utility bills, a key first step that is often overlooked is resource conservation, which can make a huge and immediate impact on your utility bills. For example, before you invest in a gray water recycling system or install a cistern for rainwater collection to lessen your dependence on water provided by utility companies, coach your family in water conservation practices. Run the dishwasher only when it is full, wash only full loads of laundry, turn off the tap when brushing your teeth, and focus on taking shorter, more efficient showers.



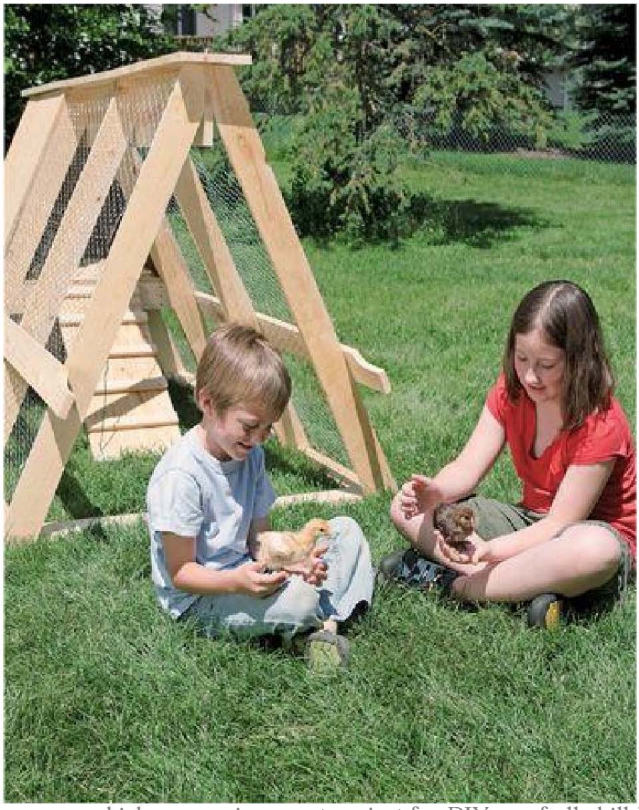
The best resources are the ones you already own. Re-using or repurposing stuff you no longer need takes some creativity, but ultimately it fills needs, not landfills. For example, this discarded dressing table found new life as a vanity cabinet in a self-sufficient homeowner's bathroom.

Increasing your own awareness of how to reuse the objects around you to benefit your self-sufficient living projects will also contribute to your success as a self-sufficient homeowner. If you plan to start your own seedlings each year, you'll need planting containers. Why not reuse plastic yogurt cups or other food containers you've already used instead of purchasing new containers? One of the nuggets of wisdom modern self-reliant homeowners must adopt is that objects do not need to be as disposable as we are led to believe. Find a way to repurpose the objects you buy, compost paper and food waste, and ensure that your tools, buildings and appliances are properly maintained to ensure that they enjoy a long and useful life in your home.

Getting Started

A key factor in finding your starting point is to develop an understanding of your goals as a self-sufficient homeowner. Self-sufficiency can contribute to many different aspects of your family's lifestyle. So before you plot out your projects, consider the tenets of self-sufficiency, as described below, and define what being self-sufficient means to you.

Producing Your Own Food: This is unquestionably the most involved aspect of a self-sufficient lifestyle for many homeowners —urban, suburban, and rural. Consider how food production and storage can ft into your home, whether you plan to start a garden or build a greenhouse, raise chickens and other small animals, build a root cellar for winter produce storage, or raise honeybees.



Building your own chicken coop is a great project for DIYers of all skill levels (see page 115). chickens provide nutritious eggs, natural garden pest-control, and organic fertilizer.

Saving on Utility Costs: Independence from local energy sources is another major draw for self-reliance enthusiasts. Whether you seek independence from utility companies because of prohibitive costs, unreliable service, or your own desire to live off the grid, many of the projects in this book can help you take first steps to get there. Bear in mind, however, that many energy- or utility-production systems do require a significant financial investment in the beginning, but will pay for themselves within the first ten years of use.

Producing Clean Energy: Many self-sufficient homeowners are more motivated by their desire to produce energy for their homes with little or no impact on the environment than they are by utility company bills. Producing non-polluting, renewable energy is increasingly achievable for residential homeowners as technological advances make the necessary equipment affordable, accessible, and easy to install.

Conserving Resources and Creating Less Waste: Conserving the earth's resources and minimizing waste is a practice that goes hand-in-hand with a self-sufficient lifestyle.



Collected rainwater is perfect for watering the garden or the lawn. Rain is soft and free of most pollutants, so it is perfect for plant irrigation. Learn how to make your own rain barrels—flip to page 13.



Drying produce is one way to preserve the fruits of your labor, so you can enjoy your garden's bounty through the winter months. Learn how to build a simple solar food dryer on page 86.



Even if you don't have a lot of space, you can use any sunny spot to grow produce in containers. A strawberry barrel like this can house up to 25 feet of strawberry plants and only takes up 2 square feet of space. To make your own barrel, see page 46.

DIY Projects





Collecting Rainwater

Practically everything around your house that requires water loves the natural goodness that's provided with soft rainwater. With a simple rain barrel, you can collect rainwater to irrigate your garden or lawn, water your houseplants, or top off swimming pools and hot tubs. A ready supply of rainwater is also a reliable stand-by for emergency use if your primary water supply is interrupted.



Rainwater that is collected in a rain barrel before it hits the ground is free of many contaminants that water picks up as it filters through soil. This soft, warm (and free) water is perfect for plants, lawns, and many other outdoor applications.

Collecting rainwater runoff in rain barrels can save thousands of gallons of tap water each year. A typical 40 × 40-ft. roof is capable of collecting 1,000 gallons of water from only one inch of rain. A large rainwater collection system that squeezes every drop from your roof can provide most—or sometimes all—of the water used throughout the home, if it's combined with large cisterns, pumps, and purification processing.

Sprinkling your lawn and garden can consume as much as 40 percent of the total household water use during the growing season. A simple rain barrel system that limits collected water to outdoor (nonpotable) use only, like the rain barrels described on the following pages, can have a big impact on the self-sufficiency of your home, helping you save on utility expenses and reducing the energy used to process and purify water for your lawn and garden. Some communities now offer subsidies for rain barrel use, offering free or reduced-price barrels and downspout connection kits. Check with your local water authority for more information. Get smart with your water usage, and take advantage of the abundant supply from above.

Rain Barrels

Rain barrels, either built from scratch or purchased as a kit, are a great way to irrigate a lawn or garden without running up your utilities bill. The most common systems include one or more rain barrels (40 to 80 gallons) positioned below gutter downspouts to collect water runoff from the roof. A hose or drip irrigation line can be connected to spigot valves at the bottom of the rain barrel. You can use a single barrel, or connect several rain barrels in series to collect and dispense even more rainwater.

Plastic rain barrel kits are available for purchase at many home centers for around $100. If kit prices aren't for you, a rain barrel is easy to make yourself for a fraction of the price. The most important component to your homemade barrel is the drum you choose.

Obtaining a Barrel



Practically any large waterproof container can be used to make a rain barrel. One easily obtained candidate is a trash can, preferably plastic, with a snap-on lid. A standard 32-gallon can will work for a rain barrel, but if you can find a 44-gallon can choose it instead. Although wood barrels are becoming more scarce, you can still get them from wineries. A used 55-gallon barrel can be obtained free or for a small charge from a bulk food supplier. Most 55-gallon barrels today are plastic, but some metal barrels are still floating around. Whatever the material, make sure the barrel did not contain any chemical or compound that could be harmful to plants, animals, or humans. If you don't know what was in it, don't use it. Choose a barrel made out of opaque material that lets as little light through as possible, reducing the risk of algae growth.

A barrelful of water is an appealing breeding ground for mosquitoes and a perfect incubator for algae. Filters and screens over the barrel opening should prevent insect infestation, but for added protection against mosquitoes add one tablespoon of vegetable oil to the water in the barrel. This coats the top surface of the stored water and deprives the larvae of oxygen.

TOOLS & MATERIALS

Barrel or trash can
drill with spade bit
Jigsaw
Hole saw
Barb fitting with nut for overflow hose
1-1/2" sump drain hose for overflow
3/4" hose bibb or sillcock
3/4" male pipe coupling
3/4" bushing or bulkhead connector
Channel-type pliers
Fiberglass window screening
Cargo strap with ratchet
Teflon tape
Silicone caulk

How to Make a Rain Barrel



1 Cut a large opening in the barrel top or lid. Mark the size and shape of your opening —if using a bulk food barrel, mark a large semi-circle in the top of the barrel. If using a plastic garbage can with a lid, mark a 12"-dia. circle in the center of the lid. Drill a starter hole, and then cut out the shape with a jigsaw.



2 Install the overflow hose. Drill a hole near the top of the barrel for the overflow fitting. Thread the barb fitting into the hole and secure it to the barrel on the inside with the retainer nut and rubber washer (if provided). Slide the overflow hose into the barbed end of the barb elbow until the end of the hose seats against the elbow flange.



3 Drill the access hole for the spigot (either a hose bibb or sillcock brass or PVC). Tighten the stem of the sillcock onto a threaded coupling inserted into the access hole. Inside the barrel a rubber washer is slipped onto the coupling end and then a threaded bushing is tightened over the coupling to create a seal. Apply a strip of Teflon tape to all threaded parts before making each connection. Caulk around the spigot with clear silicone caulk.



4 Screen over the opening in the top of the barrel. Lay a piece of fiberglass insect mesh over the top of the trash can and secure it around the rim with a cargo strap or bungee cord that can be drawn drum-tight. Snap the trash can lid over the top. Once you have installed the rain barrel periodically remove and clean the mesh.

How to Install a Rain Barrel



Whether you purchase a rain barrel or make your own from scratch or a kit, how well it meets your needs will depend on where you put it and how it is set up. Some rain barrels are temporary holding tanks that store water runoff just long enough to direct it into your yard through a hose and drip irrigation head. Other rain barrels are more of a reservoir that supplies water on-demand by filling up watering cans or buckets. If you plan to use the spigot as the primary means for dispensing water, you'll want to position the rain barrel well off the ground for easy access (raising your rain barrel has no effect on water pressure).

In addition to height, other issues surrounding the placement of your rain barrel (or rain barrels) include the need to provide a good base, orientation of the spigot and overflow, the position relative to your downspouts, and how to link more than one rain barrel together. **TIP**: Wherever possible, locate your rain barrel in a shaded area. Sunlight encourages algae growth, especially in barrels that are partially translucent.

TOOLS & MATERIALS

Drill/driver
Screwdriver
Hack saw
Rainbarrel
Hose & fittings
Base material (pavers)
Downspout adapter and extension
Teflon tape



1 Select a location for the barrel under a downspout. Locate your barrel as close to the area you want to irrigate as possible. Make sure the barrel has a stable, level base.



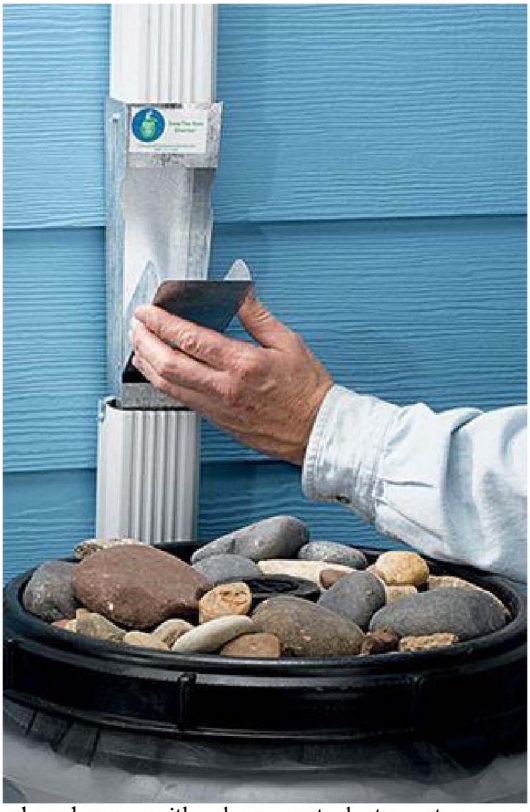
2 Install the spigot. Some kits may include a second spigot for filling watering cans. Use Teflon tape at all threaded fittings to ensure a tight seal. Connect the overflow tube, and make sure it is pointed away from the foundation.



3 Cut the downspout to length with a hacksaw. Reconnect the elbow fitting to the downspout using sheet-metal screws. Attach the cover to the top of the rain barrel. Some systems include a cover with porous wire mesh, to which the downspout delivers water. Others include a cover with a sealed connection (next step).



4 Link the downspout elbow to the rain barrel with a length of flexible downspout extension attached to the elbow and the barrel cover.



Variation: If your barrel comes with a downspout adapter, cut away a segment of downspout and insert the adapter so it diverts water into the barrel.



5 Connect a drip irrigation tube or garden hose to the spigot. A Y-fitting, like the one shown here, will let you feed the drip irrigation system through a garden hose when the rain barrel is empty.



6 If you want, increase water storage by connecting two or more rain barrels together with a linking kit, available from many kit suppliers.


2

Collecting Gray Water

Gray water is a term used to describe wastewater from your water source that is free of contaminants like toilet waste and garbage disposal remains. Water that has come into contact with these types of contaminants is referred to as “black water” and its reuse is strictly prohibited for public health reasons. Wastewater generated directly from the tap (usually while you’re waiting for the tap water to heat up or cool down) contains very few or no contaminants, such as soap, cleaning chemicals, food waste, or other added organic and inorganic material.



A small gray water recovery sink that drains automatically to a reservoir makes it easy to reuse gray water for watering plants or gardens. Gray water systems like this make it easy to recycle thousands of gallons of clean tap water each year.

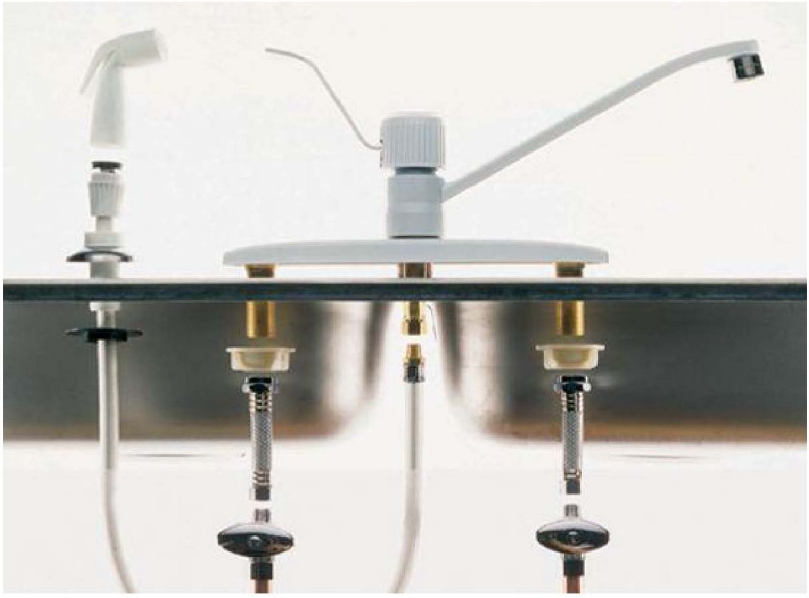
Gray water can be collected easily and used for many household purposes without treatment or filtration. It is not suitable for consumption, however. Gray water that contains some contaminants, such as laundry suds, dish soap, or shower/bath water can be used for some limited purposes, such as flushing toilets.

A simple way to capture gray water for reuse is to install a diverter in the form of a small sink basin and drain. Instead of leading to the sewer, the diverter's drain is directed to a closed receptacle, usually in the basement or outdoors. The captured water can be used for watering plants or the lawn. To avoid allowing bacteria to fester in the gray water receptacle, do not allow the water to stagnate.



Removing a Sprayer

Remove your old sink sprayer to clear an opening for the diverter sink in your sink deck. The hose that supplies the sprayer usually is attached to the base of the faucet valve. You'll need to disconnect it and tighten a screw-on tube cap onto the bottom of the tube.

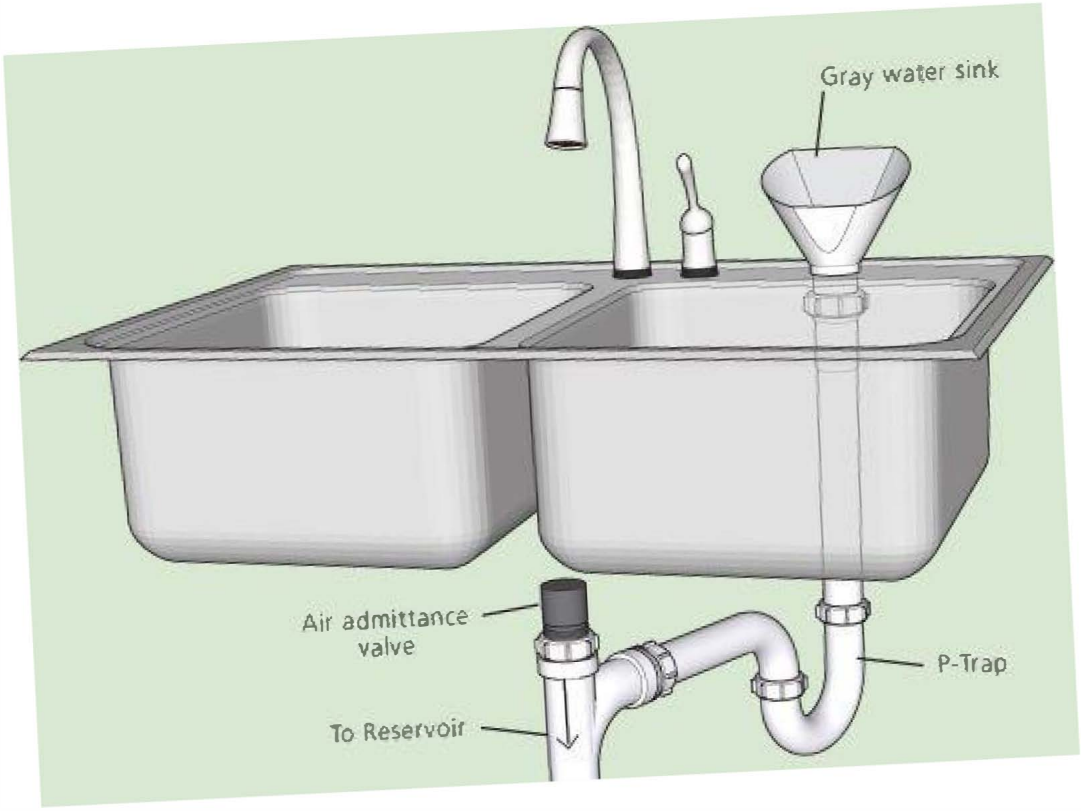


The gray water collection sink seen in this project is a fairly simple technology. Advanced recovery systems are designed to help you reuse wastewater of many types. They are complex and can involve double-plumbing throughout parts of your home, along with water purification processes and chemicals, holding tanks, plumbing switches, pumps, subsurface irrigation systems, and other components. If you're committed to reusing as much water as you can for as many purposes as possible, hire a professional to design the best system for your family's needs.

Installing a Gray Water Recovery Sink

The Envirosink gray water diverter apparatus installed in this project is available for sale online and from "Green" home retailers (See Resources, page 158.) It is designed to be mounted in a kitchen sink deck knockout—usually the one reserved for the sprayer or the soap dispenser. It can be used with any kitchen faucet—you simply spin the faucet to empty into the diverter.

Once it is diverted from the sink drain by the collection sink, the gray water is directed through a hose to a reservoir from which it can be dispensed easily for general household use. The reservoir should be a sealed tank with an overflow fitting that leads to the home drain/waste system (if indoors) or a well-drained runoff area (if outdoors). The plumbing for the runoff system should include a P-trap and an air admittance valve (or other backflow preventer).


Gray water sink
Air admittance valve
P-Trap
To Reservoir

TOOLS & MATERIALS

Drill
Eye protection
Gray water sink kit
(See resources, page 158)
Caulk
1/8" rubber washer
Flange nut
Clean rag
1-1/2"-dia. drain tubes
Power miter saw or ratcheting
plastic-pipe cutter
Solvent glue
Large bucket

How to Install a Gray Water Diverter Sink



1 Choose the best spot for the diverter sink to be mounted. Usually, this means taking over an unused knockout in your sink deck or removing a sprayer or soap dispenser. Otherwise, you can drill a hole for the diverter as close as possible to the diverter.



2 Attach the diverter sink's drain tailpiece to the sink deck or countertop. Apply a small bead of kitchen and bath caulk around the edges of the hole and press the tailpiece flange into the caulk. From below, slip a 1/8" rubber washer onto the tailpiece and then hand-tighten a flange nut.



3 Assemble the sink drain system completely before installing it as a unit. Here, an air admittance valve is being solvent-glued to a drain stub from the drain P-trap. You'll need to run additional drain pipe to supply water to your reservoir. Contact a plumbing professional if you do not have experience with home plumbing.



4 Hook up the drain assembly to the tailpiece from the diverter sink. Run drain pipe to your water storage reservoir tank, making sure the tank is equipped with an overflow valve and tubing that leads into the main drain system.


3

Composting

The byproducts of yard maintenance and food preparation accumulate rapidly. Everyday yardcare alone creates great heaps of grass clippings, trimmings, leaves, branches, and weeds. Add to this the potato peelings, coffee grounds, apple cores, and a host of organic kitchen leavings. The result is a large mass of organic matter that is far too valuable a resource to be simply dumped into the solid waste stream via curbside garbage collection. Yard waste and kitchen scraps can be recycled into compost and incorporated back into planters or garden beds as a nutrient-rich (and cost-free) soil amendment.



Composting turns yard waste and kitchen scraps into a valuable soil amendment.



Managed Composting

With the right conditions, you can speed up Mother Nature's course and yield several helpings of fresh compost for your yard each season. This is called managed composting, as opposed to passive composting, when you allow a pile of plant debris and such to decompose on its own. The conditions must be just right to manage compost and speed the process. You'll need a balance of carbon and nitrogen, the right temperature, good air circulation, and the right amount of water. By mixing, chopping materials, and monitoring conditions in your compost pile, you'll increase your yield each season.

Compost is nature's own potting soil, and it effectively increases soil porosity, improves fertility, and stimulates healthy root development. Besides, making your own soil amendment through composting is much less expensive than buying commercial materials.

So how does garbage turn into plant food? The process works like this: Organisms such as bacteria, fungi, worms, and insects convert compost materials into humus, a loamy, nutrient-rich soil. Humus is the end goal of composting. Its production can take a couple of years if left undisturbed, or it can be sped up with some help from your pitchfork and a little livestock manure.

Although composting occurs throughout nature anywhere some organic matter hits the earth, in our yards and gardens it is always a good idea to contain the activity in a designated area, like a compost bin. Functionally, there are two basic kinds of bins: multi-compartment compost factories that require a fair amount of attention from you and hidden heaps where organic matter is discarded to rot at its own pace. Both approaches are valid and

both will produce usable compost. The main compost bin project seen on p. 28 is an example of the more passive style. At roughly one cubic yard in volume, it can handle most of your household organic waste and some garden waste. If you have a higher volume of organic waste or want to use a three-bin approach to staged composting, simply build additional bins.

Compost Variables

Air: The best microbes for decomposing plant materials are aerobic, meaning they need oxygen. Without air, aerobic microbes die and their anaerobic cousins take over. Anaerobic microbes thrive without oxygen and decompose materials by putrefaction, which is smelly and slow. Your goal is aerobic activity, which smells musty and loamy, like wet leaves. Improve air circulation in your compost bin by ensuring air passageways are never blocked. Intersperse layers of heavier ingredients (grass clippings, wet leaves) with lighter materials like straw, and turn the pile periodically with a garden fork or pitchfork to promote air circulation.

Water: Compost should be as wet as a wrung-out sponge. A pile that's too wet chokes out necessary air. A too-dry pile will compost too slowly. When adding water to a compost pile, wet in layers, first spraying the pile with a hose, then adding a layer of materials.

Temperature: A fast-composting pile produces quite a bit of heat. On a cool morning, you might notice steam rising from the pile. This is a good sign. Track the temperature of your pile and you'll know how well it's progressing. Aim for a constant temperature between 140 and 150 degrees Fahrenheit, not to exceed 160 degrees. To warm up a cool pile, agitate it to increase air circulation and add nitrogen-dense materials like kitchen waste or grass clippings. A pile about three feet high and wide will insulate the middle of the pile and prevent heat from escaping. You'll know the compost process is complete when the pile looks like dirt and is no longer generating extraordinary heat.



Called "black gold" by home gardeners, compost can be generated on-site and added to any planting bed, lawn, or container for a multitude of benefits. Sifting the compost before you introduce it to your yard or garden is recommended.

Browns and Greens

A fast-burning compost pile requires a healthy balance of "browns" and "greens." Browns are high in carbon, which food energy microorganisms depend on to decompose the pile. Greens are high in nitrogen, which is a protein source for the multiplying microbes. A ratio of three-to-one brown-to-green materials is a good target.



Browns: Dry brown plant material, straw, dried brown weeds, wood chips, some saw dust (use with caution—avoid saw dust from chemically treated wood)



Greens: Grass clippings, kitchen fruit and vegetable scraps, green leaves, and manure

Note: If you use chemical lawn care products on your lawn, do not include grass clippings in your compost pile.

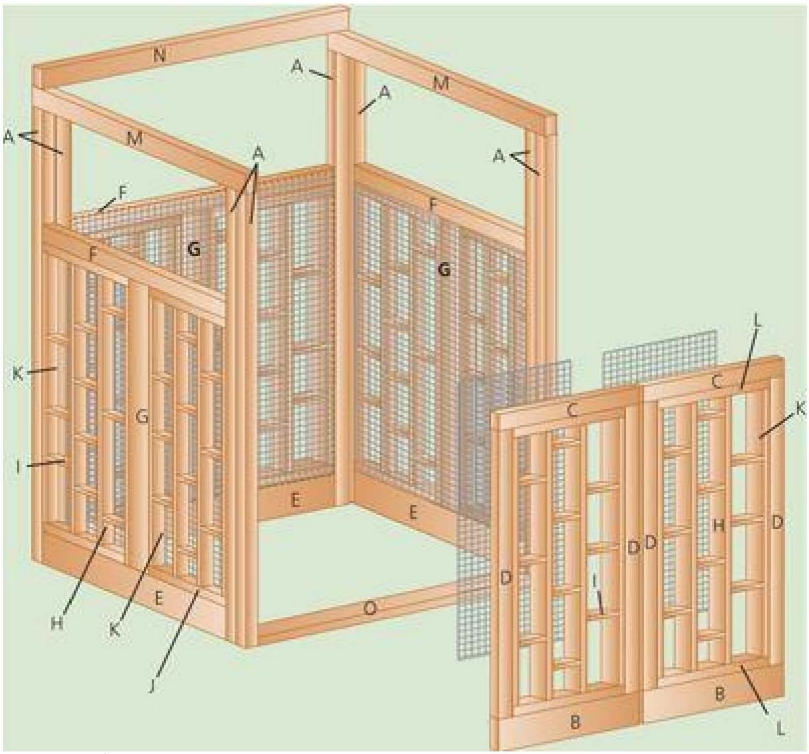


Building a Compost Bin

CUTTING LIST

Key	Part	No.	Dim.	Material
A	Post	8	1½ × 1¾ × 48"	Cedar
B	Door rail	2	1½ × 3½ × 16"	"
C	Door rail	2	1½ × 1¾ × 16"	"
D	Door stile	4	1½ × 1¾ × 30½"	"
E	Panel rail	3	1½ × 3½ × 32½"	"
F	Panel rail	3	1½ × 1¾ × 32½"	"
G	Panel stile	3	1½ × 3½ × 30½"	"
H	Infill	16	¾ × 1½ × 30½"	"
I	Filler	80	¾ × 1½ × 4"	"
J	Panel grid	12	¾ × 1½" × Cut to fit	
K	Grid frame-v	16	¾ × 1½" × Cut to fit	Cedar
L	Door frame-h	4	¾ × 1½" × Cut to fit	"
M	Top rail-side	2	1½ × 1¾ × 39"	"
N	Top rail-back	1	1½ × 1¾ × 32½"	"
O	Front spreader	1	1½ × 3½ × 32½"	

Also need:
1/2" galvanized hardware cloth 36" by 12 ft.
U-nails (fence staples)
2 pairs 2 × 2" butt hinges
2-1/2" deck screws
Exterior wood glue
Galvanized finish screws
Exterior wood sealant



A compost bin can be very plain, or it can have just enough decorative appeal to improve the appearance of a utility area.

How to Build a Compost Bin



1 Prepare the wood stock. At most building centers and lumber yards, you can buy cedar sanded on all four sides, or with one face left rough. The dimensions in this project are sanded on all four sides. Prepare the wood by ripping some of the stock into 1-3/4"-wide strips (do this by ripping 2 × 4s down the middle on a tablesaw or with a circular saw and cutting guide).



2 Cut the parts to length with a power miter saw or a circular saw. For uniform results, set up a stop block and cut all similar parts at once.



3 Assemble the door frames. Apply exterior-rated wood glue to the mating parts and clamp them together with pipe or bar clamps. Reinforce the top joints with 3" countersunk deck screws (two per joint). Reinforce the bottom joints by drilling a pair of 3/8"-dia. × 1" deep clearance holes up through the bottom edges of the bottom rails and then driving 3" deck screws through these holes up into the stiles.



4 Assemble the side and back panels. Clamp and glue the posts and rails for each frame, making sure the joints are square. Then, reinforce the joints with countersunk 3" deck screws.



5 Hang the door frames. With the posts cut to length and oriented correctly, attach a door frame to each post with a pair of galvanized butt hinges. The bottoms of the door frames should be slightly higher than the bottoms of the posts. Temporarily tack a 1 × 4 brace across both door bottom rails to keep the doors from swinging during construction.



6 Join the panels and the door assembly by gluing and clamping the parts together and then driving 2-1/2" countersunk deck screws to reinforce the joints. To stabilize the assembly, fasten the 2 × 4 front spreader between the front, bottom edges of the side panels. Make sure the spreader will not interfere with door operation.



7 Make the grids for the panel infill areas. Use 1 × 2 cedar to make all parts. Use exterior glue and galvanized finish nails to connect the horizontal filler strips to the vertical infill pieces. Vary the heights and spacing of the filler for visual interest and to make the ends accessible for nailing.



8 Frame the grids with 1 × 2 strips cut to the correct length so each frame fits neatly inside a panel or door opening. Install the grid frames in the openings, making sure all front edges are flush.



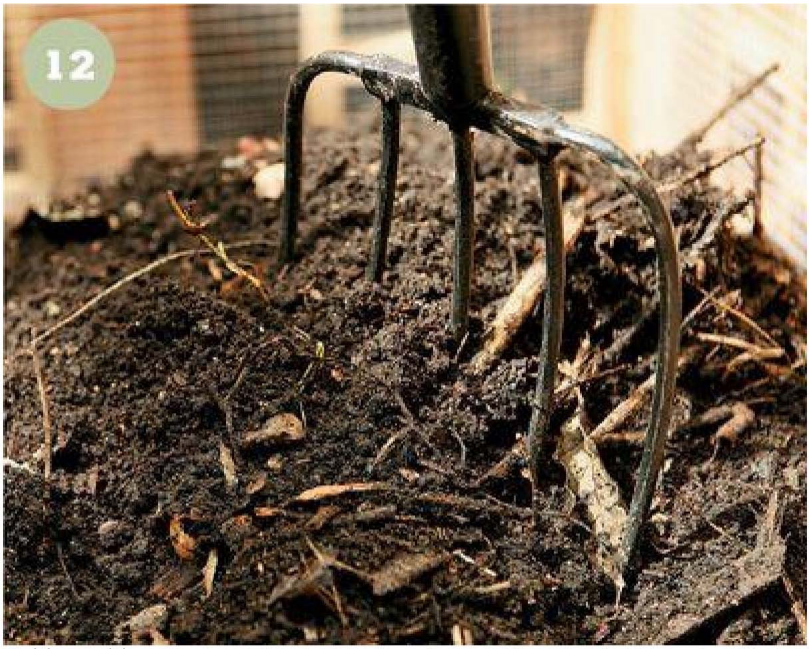
9 Attach the top rails that conceal the post tops and help tie the panels together. Attach the sides first using exterior glue and galvanized finish nails. Then, install the back rail on top of the side rails. Leave the front of the project open on top so you can load, unload, and turn over compost more easily.



10 Line the interior surfaces of the compost bin with 1/2" galvanized hardware cloth. Cut the hardware cloth to fit and fasten it with fence staples, galvanized U-nails, or narrow-crown pneumatic staples (5/8" minimum) driven every 6" or so. Make sure you don't leave any sharp edges protruding. Grind them down with a rotary tool or a file.



11 Set up the bin in your location. It should not be in direct contact with any structure. If you wish, apply a coat of exterior wood sealant to all wood surfaces—use a product that contains a UV inhibitor. **TIP:** Before setting up your compost bin, dig a hole just inside the area where the bin will be placed. This will increase you bin's capacity.



12 Add suitable organic matter to the bin and turn with a pitchfork occasionally to speed up the rate of aerobic decomposition. With a little nurturing and good conditions, a compost bin can yield several batches of usable compost in a growing season.

What to Compost, What Not to Compost

Vegetable plants soak up the materials that make up your compost, and these materials will play a vital role in the development of the vegetables that will grace your dinner table! When in doubt as to what should or shouldn't go into your compost pile for your garden, follow these general guidelines:

Great Garden Compost	Not for Compost, Please
"Clean" food scraps—including crushed eggshells, corncobs, vegetable scraps, oatmeal, stale bread, etc.	Fatty or greasy food scraps—including meat waste, bones, grease, dairy products, cooking oils, dressings, sandwich spreads, etc.
Vegetable and fruit peelings and leftovers	Fruit pits and seeds—These don't break down well and can attract rodents.
Coffee grounds and filters, tea leaves and tea bags	Metal. Remove the tea bag staples before composting!
Old potting soil	Diseased plant material
Lawn clippings	Weeds—These will only sprout in your garden! Kill the weed seeds and salvage the compostable bits by baking or microwaving the plants before adding them to your compost bin.
Prunings from your yard, chopped up in small pieces	Big chunks of yard debris or plants that are diseased or full of insect pests
Shredded leaves and pine needles	Any plant debris that has been treated with weed killer or pesticides
Shredded newspaper and telephone books—black and white pages only	Glossy color ads or wax-coated book covers
White or brown paper towels and napkins	Colored paper towels and napkins
Wood ash—use sparingly	Coal ash
Cardboard	Pizza boxes or other wax-coated food boxes
Livestock manure	Cat, dog, or other pet waste, which may contain meat products or parasites
Sawdust, wood chips, and woody brush	Sawdust from wood treated with preservatives
Straw or hay—the greener, the better!	
Wilted floral bouquets	


4

Raised Beds

Raised garden beds offer several advantages over planting at ground level. When segregated, soil can be amended in a more targeted way to support high density plantings. Also, in raised garden beds, soil doesn't suffer compaction from foot traffic or machinery, so plant roots are free to spread and breathe more easily. Vegetables planted at high densities in raised beds are placed far enough apart to avoid overcrowding, but close enough to shade and choke out weeds. In raised beds, you can also water plants easily with soaker hoses, which deliver water to soil and roots rather than spraying leaves and inviting disease. And if your plants develop a fungus or another disorder, it is easier to treat and less likely to migrate to other plants in a raised bed situation.



Raised garden beds make great vegetable gardens—they're easy to weed, simple to water, and the soil quality is easier to control, ensuring that your vegetable plants yield bountiful fresh produce. Your garden beds can be built at any height up to waist-level. It's best not to build them much taller than that, however, to make sure you can reach the center of your bed.



Bed Positions

If you're planting low-growing crops, position the bed with a north-south orientation, so both sides of the bed will be exposed to direct sunlight. For taller crops, position the bed east-west.

Raised garden beds can be built in a wide variety of shapes and sizes, and can easily be customized to fit the space you have available on your property. Just make sure you can reach the center easily. If you can only access your raised bed from one side, it's best to build it no wider than 3 ft. Beds that you can access from both sides can be as wide as 6 ft., as long as you can reach the center. You can build your raised bed as long as you'd like.

Raised garden beds can be built from a wide variety of materials: 2× lumber, 4 × 4 posts, salvaged timbers, even scrap metals and other recycled goods. Make sure any lumber you choose (either new or salvaged) hasn't been treated with creosote, pentachlorophenol, or chromated copper arsenic (CCA). Lumber treated with newer, non-arsenate chemicals at higher saturation levels is rated for ground contact and is also a safe choice for bed frames. Rot-resistant redwood and cedar are good choices that will stand the test of time. Other softwoods, including pine, tamarack, and cypress, will also work, but can be subject to rot and may need to be replaced after a few years.

Vegetable Plant Compatibility Chart

Vegetable	Loves	Incompatible with	Planting Season
Asparagus	Tomatoes, parsley, basil		Early spring
Beans (bush)	Beets, carrots, cucumbers, potatoes	Fennel, garlic, onions	Spring
Cabbage & broccoli	Beets, celery, corn, dill, onions, oregano, sage	Fennel, pole beans, strawberries, tomatoes	Spring
Cantaloupe	Corn	Potatoes	Early summer
Carrots	Chives, leaf lettuce, onion, parsley, peas, rosemary, sage, tomatoes	Dill	Early spring
Celery	Beans, cabbages, cauliflower, leeks, tomatoes		Early summer
Corn	Beans, cucumbers, peas, potatoes, pumpkins, squash		Spring
Cucumbers	Beans, cabbages, corn, peas, radishes	Aromatic herbs, potatoes	Early summer
Eggplant	Beans	Potatoes	Spring
Lettuce	Carrots, cucumbers, strawberries		Early spring
Onions & garlic	Beets, broccoli, cabbages, eggplant, lettuce, strawberries, tomatoes	Peas, beans	Early spring
Peas	Beans, carrots, corn, cucumbers, radishes, turnips	Chives,	Early spring
Potatoes	Beans, cabbage, corn, eggplant, peas	Cucumber, tomatoes, raspberries	Early spring
Pumpkins	Corn	Potatoes	Early summer
Radishes	Beans, beets, carrots, cucumbers, lettuce, peas, spinach, tomatoes		Early spring
Squash	Radishes	Potatoes	Early summer
Tomatoes	Asparagus, basil, carrots, chive, garlic, onions, parsley	Cabbages, fennel, potatoes	Dependent on the variety
Turnips	Beans, peas		Early spring



Watering Raised Beds

When the soil inside the planting bed pulls away from the edges of the bed, it's time to water. The best time of day to water is in the late afternoon or early- to mid-morning. Avoid watering in midday, when the sun is hottest and water will quickly evaporate, or near sundown or at night, when too much moisture in the soil can cause mold and fungus to grow.

Companion Planting

The old adage is true—some vegetables do actually get along "like peas and carrots." Some species of vegetables are natural partners that benefit from each other when planted close. On the other hand, some combinations are troublesome, and one plant will inhibit the growth of another. You can plant these antagonists in the same garden—even in the same raised garden bed—just don't place them side by side. Use the table on p. 34 to help you plan out your raised garden beds to ensure that your plants grow healthy, strong, and bear plentiful fruit.

Start with Healthy Soil

The success or failure of any gardening effort generally lies beneath the surface. Soil is the support system for all plants—it provides a balanced meal of the nutrients that plants' roots need to grow deep and strong. If you plan to fill your raised beds with soil from your property, it's a good idea to have the soil tested first to assess its quality. Take a sample of your soil and submit it to a local agricultural extension service—a basic lab test will cost you between $15 and $25 and will give you detailed information about the nutrients available in your property's soil. Mixing soil from your property with compost, potting soil, or other additives is a smart and inexpensive way to improve its quality. After you've filled your beds with soil, add a three-inch layer of mulch to the top to lock in moisture and keep your good soil from blowing away in strong winds. Lawn clippings, wood, or bark chips, hay and straw, leaves, compost, and shredded newspaper all work well as mulch materials.



Sprinklers with high, arching spray patterns are afflicted by excess water evaporation, but if you choose a small, controllable sprinkler with a water pattern that stays low to the ground you can deliver water to your raised bed with minimal loss.

How to Build a Raised Bed



1 This basic but very sturdy raised bed is made with 4 × 4 landscape timbers stacked with their ends staggered in classic log-cabin style. The corners are pinned together with 6" galvanized spikes (or, you can use timber screws). It is lined with landscape fabric and includes several weep holes in the bottom course for drainage. Consider adding a 2 × 8 ledge on the top row. Corner finials improve the appearance and provide hose guides to protect the plants in the bed.



2 Create an outline around your garden bed by tying mason's string to the stakes. Use a shovel to remove the grass inside the outline, then dig a 4"-wide trench for the first row of timbers around the perimeter. Lay the bottom course of timbers in the trenches. Where possible, add or remove soil as needed to bring the timbers to level—a level bed frame always looks better than a sloped one. If you do have a significant slope to address, terrace the beds.



3 Add the second layer, staggering the joints. Drill pilot holes at the corners and drive 6" galvanized spikes (or 6" to 8" timber screws) through the holes—use at least two per joint. Continue to build up layers in this fashion, until your bed reaches the desired height.



4 Line the bed with landscape fabric to contain the soil and help keep weeds out of the bed. Tack the fabric to the lower part of the top course with roofing nails. Some gardeners recommend drilling 1"-dia. weep holes in the bottom timber course at 2-ft. intervals. Fill with a blend of soil, peat moss, and fertilizer (if desired) to within 2 or 3" of the top.

How to Build a Raised Bed from a Kit



1 Raised garden bed kits come in many styles. Some have modular plastic or composite panels that fit together with grooves or with hardware. Others feature wood panels and metal corner hardware. Most kits can be stacked to increase bed height.



2 On a flat surface, assemble the panels and corner brackets (or hinge brackets) using the included hardware. Follow the kit instructions, making sure all corners are square.



3 Set the box down, experimenting with exact positioning until you find just the spot and angle you like. Be sure to observe the sun over an entire day when choosing the sunniest spot you can for growing vegetables. Cut around the edges of the planting bed box with a square-nose spade, move the box, and then slice off the sod in the bed area.



4 Set the bed box onto the installation site and check it for level. Add or remove soil as needed until it is level. Stake the box to the ground with the provided hardware. Add additional box kits on top of or next to the first box. Follow the manufacturer's instructions for connecting the modular units. Line the bed or beds with landscape fabric and fill with soil to within 2" or so of the top.


5

Container Gardening

If you're short on yard space but have a sunny spot like a balcony, stoop, porch, roof, or even windowsill, then you have the potential to plant a productive vegetable garden. Many plants flourish in small planters or other portable containers, and with a few well-managed containers, you can yield a sizable bounty for a couple or small family. In some ways, container gardening is easier than having a full-blown vegetable garden: There are fewer weeds (if any), pests are less problematic, and diseases are easier to avoid. You also need fewer tools and plants can easily be moved to accommodate temperature fluctuations and light/shade patterns. If you're a beginner gardener just wanting to try your hand at growing your own food, container gardening could be a great solution for you.



If you've never tried gardening, container gardening is a good way to start.



Fresh soil

Do not reuse soil if you're growing tomatoes or other plants that are susceptible to blight and fungus. After the growing season is concluded, collect the soil from sensitive plant containers and disperse it into hardy planting beds.

The key to successful container gardening is water. Because of their limited size, even the largest containers simply cannot hold the amount of water the plants need to thrive without watering once every day—extremely thirsty plants may even need to be watered more frequently than that. Vegetable plants are especially thirsty, but herbs and fruit trees or bushes need careful watering as well. Mature tomato plants may need as much as a gallon of water every day to grow those juicy, delicious fruits. If you bury your finger in the pot and you feel any dry soil—even 2" down—it's time to water.

Soil in container gardens is important too. A reliable rule of thumb is to use a 50/50 mix of potting soil to compost. Soil from your property typically won't hold water as well as potting soil on its own, so it's best not to use it in container gardens without adding a significant amount of organic fertilizer, which you can buy at the garden center or mix yourself. The following pages provide guidelines about the types of containers you can use and step-by-step instructions to help you build your own planter boxes.

What to Grow

Most plants that grow well in your garden will also thrive in containers. Root vegetables are perhaps the only exception to this rule. Keep in mind that the larger the plant, the larger the container you'll need. Generally, the plant should not be more than twice the height of the pot or 1-1/2 times as wide. Use the guidelines below as a rough guide.

Containers 4 to 6" deep: Mustard greens, radishes, and spinach can all grow in shallow containers.

Containers at least 8" deep: Corn (container must be at least 21" wide, however, and house at least three plants to assure pollination), kale, lettuce.

Containers at least 12" deep: Beans, beets, brussel sprouts, cabbage (should also be pretty wide), carrots, chard, collards, kohlrabi, onion, peas, turnips, zucchini.

Containers at least 16" deep: Cucumber, eggplant, peppers.

Containers at least 20" deep: Broccoli, bok choy, Chinese cabbage.

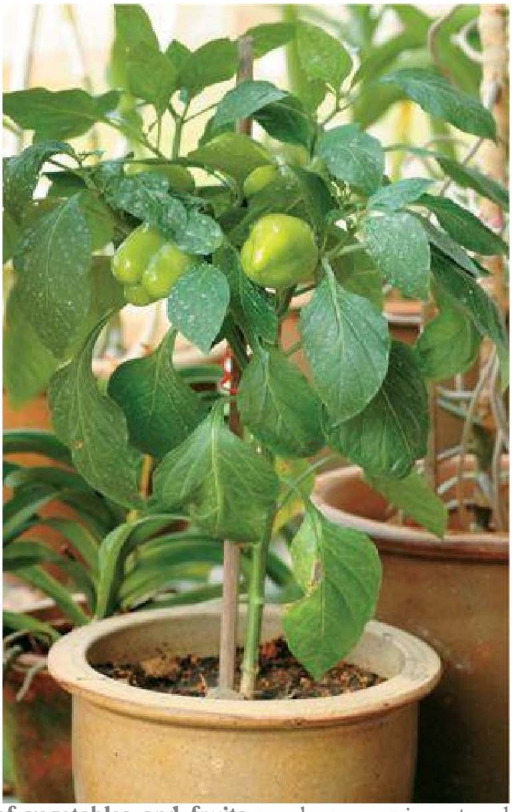
More than 24" deep: Squash, tomatoes.

Container Types and Recommendations

As a container gardener, you'll quickly discover that the universe of usable containers is infinitely larger than the plain clay flowerpot. Essentially, any sturdy, watertight container will do. Large containers like wine barrels or old wash tubs and smaller containers like an ice cream pail or 5-gallon bucket can all be good for different kinds of plants. Large wooden troughs and DIY planter boxes can be customized to your garden (and are fun to make, too). When building your own planters, it's a good idea to line the inside with perforated polyethylene sheeting before adding potting soil to protect the wood from rot and to make it easier to empty out soil after a season.

Always make sure that the container you choose did not previously hold any kind of chemical and, if it does not already have them, drill drainage holes near the bottom of the container before filling with soil. If you'll be using large containers, it's usually a good idea to place them on a platform fitted with casters before filling them with potting soil.

Self-watering pots make container gardening less of a drain on your time. These containers are, essentially, a flowerpot set just above a reservoir of water. With this type of container, the soil above will wick up moisture from the reservoir as it needs it—keeping the soil consistently moist throughout and eliminating the possibility of over-watering. With a self-watering container, you may only need to add water every three to four days, and your plants will likely be less stressed. Ideally, your plants will therefore provide a more sizable crop at the end of the season.



Many varieties of vegetables and fruits can be grown in pots, planters, and other vessels—just make sure to select a container that is the right size for your plant and always add ample drainage holes if they're not already present.



Spinach, leaf lettuce and a few shallots co-exist in this self-watering planter. Self-watering containers have a water reservoir below to keep the soil in the pot moist. All you have to do is keep the reservoir full, and rainfall may even take care of this for you.

Planter Boxes

Decorating a garden is much like decorating a room in your home—it's nice to have pieces that are adaptable enough that you can move them around occasionally and create a completely new look. After all, most of us can't buy new furniture every time we get tired of the way our living rooms look. And we can't build or buy new garden furnishings every time we want to rearrange the garden.

That's one of the reasons this trio of planter boxes works so well. In addition to being handsome—especially when flowers are bursting out of them—they're incredibly adaptable. You can follow these plans to build a terrific trio of planter boxes that will go well with each other and will complement most gardens, patios, and decks. Or you can tailor the plans to suit your needs. For instance, you may want three boxes that are exactly the same size. Or you might want to build several more and use them as a border that encloses a patio or frames a terraced area.

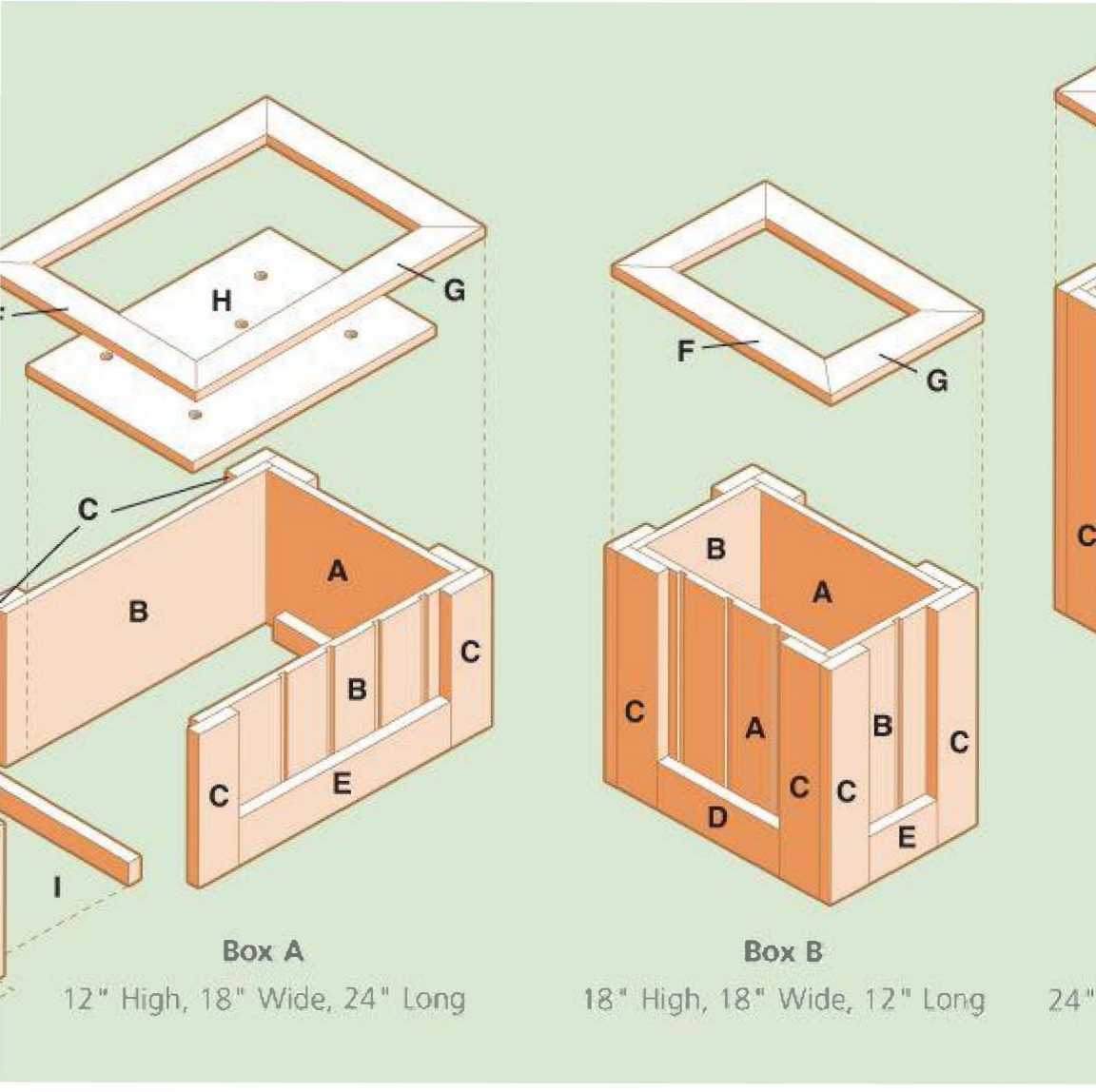
Whatever the dimensions of the boxes, the basic construction steps are the same. If you decide to alter the designs, take a little time to figure out the new dimensions and sketch plans. Then devise a new cutting list and do some planning so you can make efficient use of materials. To save cutting time, clamp together parts that are the same size and shape and cut them as a group (called gang cutting).

When your planter boxes have worn out their welcome in one spot, you can easily move them to another, perhaps with a fresh coat of stain, and add new plantings. You can even use the taller boxes to showcase outdoor relief sculptures—a kind of alfresco sculpture gallery.



Whether you build only one or all three, these handy cedar planters are small enough to move around your gardens and inside your greenhouse or garden shed.

Building Planter Boxes



CUTTING LIST

t	Box A Dimension	Box B Dimension	Box C Dime
d panel	⅝ × 15 × 11⅛"	⅝ × 15 × 17⅛"	⅝ × 15 × 23
e panel	⅝ × 22¼ × 11⅛"	⅝ × 10¼ × 17⅛"	⅝ × 10¼ ×
rner trim	⅞ × 3½ × 11⅛"	⅞ × 3½ × 17⅛"	⅞ × 3½ × 2
tom trim	⅞ × 3½ × 9¼"	⅞ × 3½ × 9¼"	⅞ × 3½ × 9
tom trim	⅞ × 3½ × 17"	⅞ × 3½ × 5"	⅞ × 3½ × 5
) cap	⅞ × 1½ × 18"	⅞ × 1½ × 18"	⅞ × 1½ × 1
) cap	⅞ × 1½ × 24"	⅞ × 1½ × 12"	⅞ × 1½ × 1
tom panel	¾ × 14½ × 19½"	¾ × 14½ × 8½"	¾ × 14½ ×
at	⅞ × 1½ × 12"	⅞ × 1½ × 12"	⅞ × 1½ × 1

eflect the actual size of dimension lumber.

TOOLS AND MATERIALS

Tape measure
Circular saw
Straightedge
Drill
Finishing sander
Miter box and backsaw
(3) 8-ft. cedar 1 × 2s
(6) 8-ft. cedar 1 × 4s
4 × 8-ft. sheet of 5/8" T1-11 siding
2 × 4-ft. piece 3/4" CDX plywood
1-1/4" galvanized deck screws
1-5/8" galvanized deck screws
6d galvanized finish nails
Exterior wood stain
Paintbrush
Landscape fabric

How to Build Planter Boxes



1 Cut all the wood parts to size according to the Cutting List on page 43. Use a circular saw and a straightedge cutting guide to rip siding panels (if you have access to a tablesaw, use that instead). You can make all three sizes, or any combination you choose.



2 Assemble the box frame. Place the end panel face down and butt it against a side panel. Mark the locations of several fasteners on the side panel. Drill counterbored 3/32" pilot holes in the side panel at the marked locations and fasten the side panel to the end panel with 1-5/8" deck screws. Fasten the opposite side panel the same way. Attach the other end panel with deck screws.



3 Attach the corner trim. Position one piece of corner trim flush to the corner edge and fasten to the panels with 1-5/8" galvanized deck screws driven into the trim from the inside of the box. Place the second piece of trim flush to the edge of the first piece, creating a square butt joint. Attach to the panel with 1-5/8" galvanized deck screws. For extra support, end nail the two trim pieces together at the corner with galvanized finish nails.



4 Attach the bottom trim. Fasten the bottom trim to the end and side panels, between the corner trim pieces and flush with the bottom of the box. Drive 1-1/4" deck screws through the panels from the inside to fasten the trim pieces to the box.



5 Attach the cap pieces. Cut 45° miters at both ends of one cap piece using a miter box and backsaw or a power miter saw. Tack this piece to the top end of the box, with the outside edges flush with the outer edges of the corner trim. Miter both ends of each piece and tack to the box to make a square corner with the previously installed piece. Once all caps are tacked in position and the miters are closed cleanly, attach the cap pieces using 6d galvanized finish nails.



6 Install the cleats to hold the box bottom in place. Screw to the inside of the end panels with 1-5/8" deck screws. If your planter is extremely tall, fasten the cleats higher on the panels so you won't need as much soil to fill the box. If doing so, add cleats on the side panels as well for extra support.



7 Finish and install the bottom. Cut the bottom panel to size from 3/4"-thick exterior-rated plywood. Drill several 1"-dia. drainage holes in the panel and set it onto the cleats. The bottom panel does not need to be fastened in place, but for extra strength, nail it to the cleats and box sides with galvanized finish nails.



8 Finish the box or boxes with wood sealer-preservative. When the finish has dried, line the planter box with landscape fabric, stapling it at the top of the box. Trim off fabric at least a couple of inches below the top of the box. Add a 2"-layer of gravel or stones, then fill with a 50/50 mix of potting soil and compost. **TIP:** Add wheels or casters to your planter boxes before filling them with soil. Be sure to use locking wheels or casters with brass or plastic housings.

Building an Old-fashioned Strawberry Barrel

Container gardens aren't just for vegetables—fruit trees and berry bushes also thrive in a potted garden environment and can produce enough fruit for a family to enjoy throughout the summer. Strawberries, which typically grow in long rows or patches in the ground, can also be grown in a converted barrel. Two can be enough space to grow the equivalent of 25 feet of strawberry plants. For this project, make sure you choose everbearing strawberry varieties, and cut off runners for transplanting when they appear. Insulate your barrels with hay or straw during the winter, and you can enjoy a strawberry crop for several years. To keep your barrel going, start fresh every four or five years with new plants and new soil.



A strawberry barrel planter can grow the equivalent of 25 ft. of strawberry plants; choose everbearing varieties for best results.

TOOLS & MATERIALS

Large, clean barrel (55-gallon plastic or wood)
Pry bar or jigsaw
3"-dia. hole saw
Drill
4"-dia. PVC Pipe
Window screen or hardware cloth
Gravel
Potting soil mix
Strawberry plants

How to Build a Strawberry Barrel



1 Prepare the barrel. If your barrel has a lid or closed top, remove it with a pry bar. If your barrel does not have a lid, cut a large opening in the top with a jigsaw. Beginning about 1 ft. above the ground, use a hole saw to cut 3"-dia. planting holes around the barrel, about 10" apart. Stagger the holes diagonally in each row and space the rows about 10" apart. Leave at least 12" above the top row of holes. Flip the barrel over and drill about a half dozen 1/2"-dia. drainage holes in the bottom.



2 Prepare the watering pipe. Cut a section of 4"-dia. PVC pipe to fit inside the barrel from top to bottom. Punch or drill 3/4"-dia. holes in the pipe every 4 to 6", all the way around. Cut a section of window screen or hardware cloth to fit inside the bottom of the barrel and place it inside. Cover the screen with 2" of gravel or small rocks.



3 Begin to fill the barrel with soil. Have a friend hold the watering pipe in the center of the barrel and fill the pipe with coarse gravel. Then, begin to add soil to the bottom of the barrel, packing it firmly around the watering pipe in the bottom with a piece of scrap lumber. Add water to help the soil settle. Continuing adding soil until you reach the bottom of your first row of planting holes.



4 Add soil and plants. Carefully insert your strawberry plants into the holes, spreading the roots into a fan shape. Add soil on top of the roots and lightly water. Continue to add soil and plants, packing soil gently and watering after each planting, until you reach the top of the barrel. Do not cover the watering pipe. Plant additional strawberries on top of the barrel. Insert a hose into the watering pipe and run water for several minutes to give the barrel a good soaking.


6

Building a Cold Frame

An inexpensive foray into greenhouse gardening, a cold frame is practical for starting plants six to eight weeks earlier in the growing season and for hardening off seedlings. Basically, a cold frame is a box set on the ground and topped with glass or plastic. Although mechanized models with thermostatically controlled atmospheres and sash that automatically open and close are available, you can easily build a basic cold frame yourself from materials you probably already have around the house.



Starting plants early in a cold frame is a great way to get a head start on the growing season. A cold frame is also a great place for hardening off delicate seedlings to prepare them for transplanting.

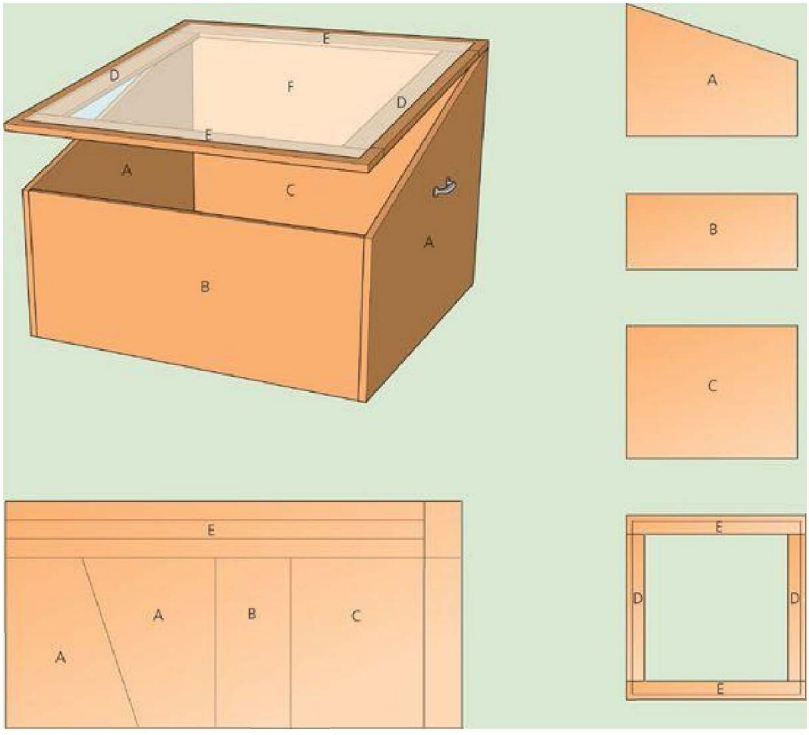
The back of the frame should be about twice as tall as the front so the lid slopes to a favorable angle for capturing sunrays. Build the frame tall enough to accommodate the maximum height of the plants before they are removed. The frame can be made of brick, block, plastic, wood, or just about any material you have on hand. It should be built to keep drafts out and soil in.

If the frame is permanently sited, position it facing south to receive maximum light during winter and spring and to offer protection from wind. Partially burying it takes advantage of the insulation from the earth, but it also can cause water to collect and the direct soil contact will shorten the lifespan of the wood frame parts. Locating your frame near a wall, rock, or building adds additional insulation and protection from the elements. **TIP:** The ideal temperature inside is 65 to 75° F during the day and 55 to 65° at night. Keep an inexpensive thermometer in a shaded spot inside the frame for quick reference. A bright spring day can heat a cold frame to as warm as 100°, so prop up or remove the cover as necessary to prevent overheating. And remember, the more you vent, the more you should water. On cold nights, especially when frost is predicted, cover the box with burlap, old quilts, or leaves to keep it warm inside.



A cold frame should only be used during the early, cooler days of the growing season when delicate seedlings need that extra protection, and for late-season frost protection. Once the warmer weather arrives and the plants are established, remove and relocate the cold frame. Ongoing usage will overheat and kill the plants. And while the clear acrylic lid on this cold frame is desirable because it is safer to work with and use than glass, too much heat buildup can cause the acrylic to warp.

Building a Cold Frame



CUTTING LIST

Key	Part	No.	Size	Material
A	Side	2	¾ x 16/28 x 36"	Ext. Plywood
B	Front	1	¾ x 16 x 36"	Ext. Plywood
C	Back	1	¾ x 28 x 36"	Ext. Plywood
D	Lid frame	2	¾ x 4 x 31"	Ext. Plywood
E	Lid frame	2	¾ x 4 x 38"	Ext. Plywood
F	Cover	1	⅛ x 37 x 38"	Plexiglas

TOOLS AND MATERIALS

(2) 3 × 3" butt hinges (ext.)
(2) 4" utility handles
(4) Corner L-brackets (3/4 × 2-1/2")
(1) 3/4" × 4 × 8 ft. Plywood (Ext.)
1/8 × 37 × 38" clear Plexiglas
Exterior caulk/adhesive
Exterior wood glue
Exterior paint
2" deck screws
#8 × 3/4" wood screws
Circular saw
Drill/driver
Pipe clamps
Straightedge cutting guide

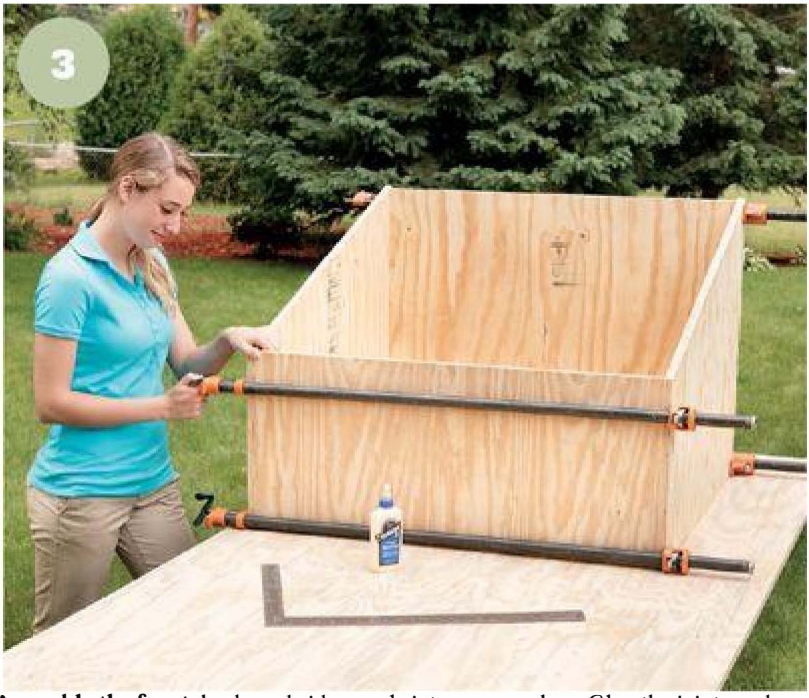
How to Build a Plywood Cold Frame



1 Cut the parts. This project, as dimensioned, is designed to be made entirely from a single 4 × 8 sheet of plywood. Start by cutting the plywood lengthwise to make a 36"-wide piece. **TIP:** Remove material in 4" wide strips and use the strips to make the lid frame parts and any other trim you may want to add.



2 Trim the parts to size with a circular saw or jigsaw and cutting guide. Mark the cutting lines first (See Diagram, p. 51).



3 Assemble the front, back, and side panels into a square box. Glue the joints and clamp them together with pipe or bar clamps. Adjust until the corners are square.



4 Reinforce the joints with 2" deck screws driven through countersunk pilot holes. Drive a screw every **4** to 6" along each joint.



5 Make the lid frame. Cut the 4"-wide strips of 3/4" plywood reserved from step 1 into frame parts. Assemble the frame parts into a square 38 × 39" frame. There are many ways to join the parts so they create a flat frame. Because the Plexiglas cover will give the lid some rigidity, simply gluing the joints and reinforcing with an L-bracket at each inside corner is adequate structurally.



6 Paint the box and the frame with exterior paint, preferably in an enamel finish. A darker color will hold more solar heat.



7 Lay thick beads of clear exterior adhesive/caulk onto the tops of the frames and then seat the Plexiglas cover into the adhesive. Clean up squeeze-out right away. Once the adhesive has set, attach the lid with butt hinges and attach the handles to the sides.



8 Move the cold frame to the site. Clear and level the ground where it will set. Some gardeners like to excavate the site slightly—see discussion on page 49.


7

Starting & Transplanting Seedlings

Add weeks to your garden's growing season by starting seeds indoors, then transplanting them to the garden after the danger of frost is past. Seedlings are available for purchase at the garden center in the spring, of course, but starting your own at home presents a number of advantages:



Seedlings need a lot of water, sunlight, and warmth in their infancy. A kitchen window or greenhouse is an ideal growing environment for propagating plants.



Using colored cups as starter containers has the advantage of letting you color-code your plants so you can avoid any confusion. Beginning gardeners often have trouble distinguishing one pot from another when they are still seedlings. Here, the red cups clearly communicate "tomato."

- Buying seeds is less expensive than buying seedlings.
- You can cull out all but the strongest seedlings, which will hopefully result in stronger plants and a more bountiful crop.
- Garden centers sell seeds for a diverse and varied array of plants, but seedlings for only the most common species. Seed catalogs introduce an entirely new selection as well.
- You can be certain that unwanted pesticides have not been used on the plants in your garden, even in their infancy.

Start your seeds eight to ten weeks before you plan to transplant them into your garden. To get started, you'll need a few small containers, a suitable growing medium, and a bright spot for the seedlings to grow—either a sunny window that receives at least six hours of bright sunlight per day, a greenhouse, or a planting table in your home that's illuminated by artificial grow lights. If you're planning to raise your seedlings by artificial light, position one or two fluorescent lighting fixtures fitted with 40-watt, full-spectrum bulbs about six inches above the seedlings. Leave fluorescent lights on for 12 to 16 hours a day—many gardeners find it helpful to connect the fixture to a timer to ensure their plants receive adequate light each day.



A 4-ft., two-bulb fluorescent light fixture that can be raised or lowered over a table is really all you need to start your vegetable plants indoors.

Growing Mediums

If you plan to use your own garden soil or compost, prepare your seedling containers in the fall, before the ground gets too cold and wet.

Almost any small container can be used to grow seedlings. Just make sure the container you use is clean and hasn't had contact with any chemical that could be poisonous to plants. Also, remember to cut a drainage hole in the bottom of your container before filling it with soil. Drainage is very important to ensure that your plants are well ventilated. Excessively moist soil can result in mold or other diseases, as well. Good options for seedling containers include:

- Peat pots or pellets
- Fiber cubes
- Used plastic jugs
- Cans (any size)
- Used plastic tubs (i.e., sour cream,
- cottage cheese, or margarine containers)
- Used yogurt cups
- Egg cartons
- Small paper cups


Potting
Mix

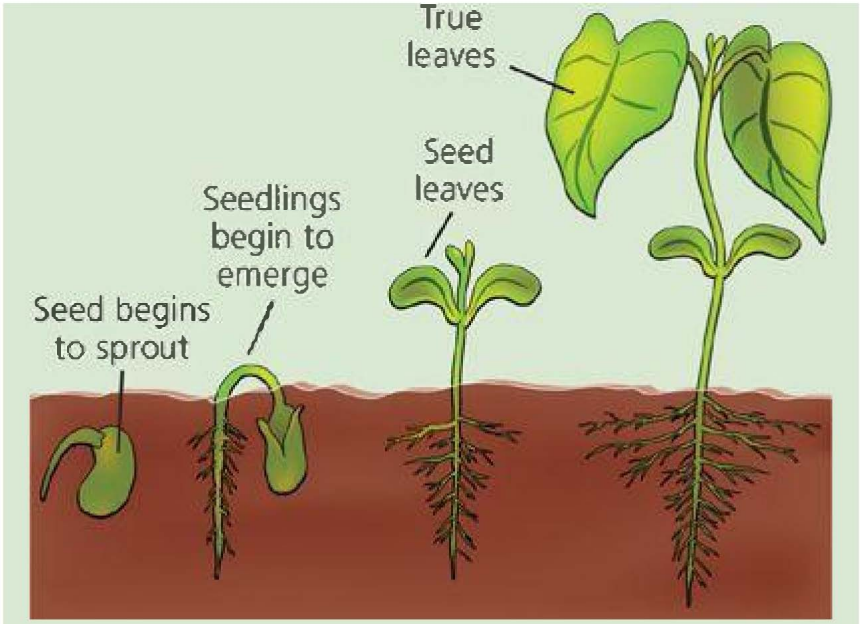
Starting Seedlings

1. Planting: Sow three to four seeds in each container according to the instructions on the seed packet—as a general rule, large seeds should be buried and small seeds can be sprinkled on top of the soil. Label the container with the type of plant and the date your seeds were planted.

2. Germination: Water the seeds whenever the containers look dry. Until the seeds sprout, keep seedlings in a dark, warm space. Cover germinating seeds with plastic bags or plastic wrap. Open the plastic for a few hours every few days to let the soil breathe, then re-close.

3. Sprouts: When the seeds sprout, remove plastic covering and move them into direct light. Seedlings need lots of light to grow. Keep the soil medium moist but not soggy. Remember, multiple light waterings are better for seedlings than the occasional soaking.

4. Culling: When the true leaves appear (see illustration), cut off all but the strongest seedling in each container at soil level. Do not pull up the unwanted seedlings, as this may damage the roots of the seedling you're cultivating. You may also choose to fertilize every week or so as your seedlings grow.



The four stages in the growth of a seedling are illustrated above. Note that seed leaves and true leaves serve different purposes and will look different. When a plant has 4 to 8 true leaves, it is ready for transplanting.

Hardening Off and Transplanting

When your seedlings have four to eight true leaves, they should be hardened off, then transplanted to the garden. Hardening off is the process of gradually introducing the plant to outdoor conditions so it is not shocked when you move it outside permanently. About two weeks before planting, place your seedlings outdoors for an hour the first day, and then gradually increase the time until your seedlings spend the whole day outside. Protect seedlings from wind and do not expose them to the midday sun for the first few days. Stop fertilizing seedlings during the last week. A cold frame is a great environment for hardening off seedlings. Seedlings can stay in a cold frame for two to three weeks, gradually getting used to the cooler air and chilly nights before they go out into the garden. Open the lid of the cold frame a little bit more each day.

Transplant your seedlings into the garden on a cloudy day or in late afternoon to avoid excessive drying from the sun. Remove seedlings gently from their containers, holding as much soil as possible around the roots (containers that are pressed from peat are not intended to be removed). Place each into a hole in your garden, spreading the roots carefully, then pack soil around the seedling to hold it straight and strong. Thoroughly soak all seedlings with a very gentle water spray after they've been planted. If you have a rain barrel or another source for untreated water, this is a perfect application for it: The chlorine in most municipal water can be harmful to delicate plants.


8

Building a Greenhouse

Utilizing a greenhouse is a great way to extend and diversify your garden, enabling you to grow more food for a longer period of time—and perhaps even grow foods that wouldn't otherwise survive in your climate. A greenhouse can be a decorative and functional building that adds beauty to your property, or a quick and easy temporary structure that serves a purpose and then disappears. The wood-framed greenhouse in this project is somewhere between these two types. The sturdy wood construction will hold up for many seasons. The plastic sheeting covering will last one to five seasons, depending on the material you choose, and is easy to replace when it starts to degrade.



A wood-frame greenhouse with sheet-plastic cover is an inexpensive, semipermanent gardening structure that can be used as a potting area as well as a protective greenhouse.

The five-foot-high kneewalls in this design provide ample space for installing and working on a conventional-height potting table. For a door, this plan simply employs a sheet of weighted plastic that can be tied out of the way for entry and exit. If you plan to go in and out frequently, you can purchase a prefabricated greenhouse door from a garden center or greenhouse materials provider. To allow for ventilation in hot weather, we built a wood-frame vent cover that fits over one rafter bay and can be propped open easily.

Where to Site Your Greenhouse

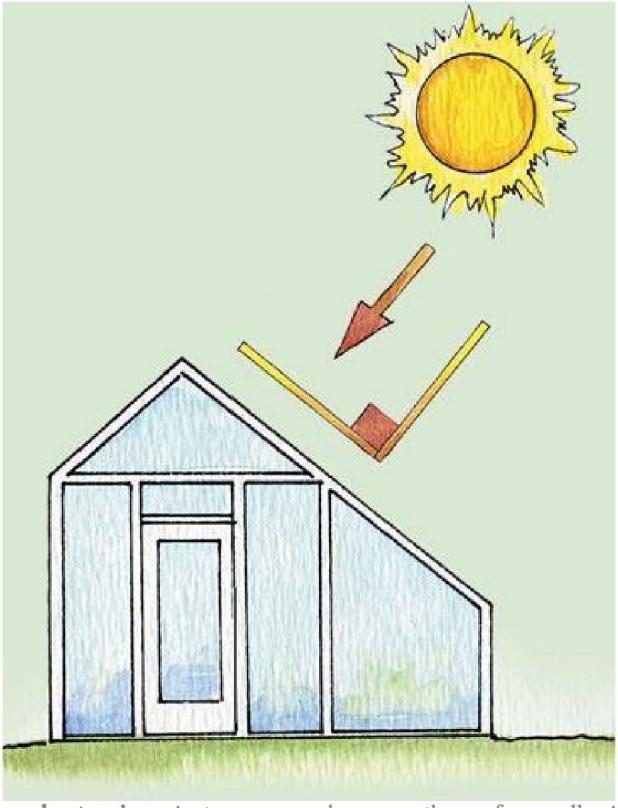
When the first orangeries (early greenhouses) were built, heat was thought to be the most important element for successfully growing plants indoors. Most orangeries had solid roofs and walls with large windows. Once designers realized that light was more important than heat for plant growth, they began to build greenhouses from glass.

All plants need at least six (and preferably 12) hours of light a day year-round, so when choosing a site for a greenhouse, you need to consider a number of variables. Be sure that it is clear of shadows cast by trees, hedges, fences, your house, and other buildings. Don't forget that the shade cast by obstacles changes throughout the year. Take note of the sun's position at various times of the year: A site that receives full sun in the spring and summer can be shaded by nearby trees when the sun is low in winter. Winter shadows are longer than those cast by the high summer sun, and during winter, sunlight is particularly important for keeping the greenhouse warm. If you are not familiar with the year-round sunlight patterns on your property, you may have to do a little geometry to figure out where shadows will fall. Your latitude will also have a bearing on the amount of sunlight available; greenhouses at northern latitudes receive fewer hours of winter sunlight than those located farther south. You may have to supplement natural light with interior lighting.

To gain the most sun exposure, the greenhouse should be oriented so that its ridge runs east to west (see illustration), with the long sides facing north and south. A slightly southwest or southeast exposure is also acceptable, but avoid a northern exposure if you're planning an attached greenhouse; only shade-lovers will grow there.



The ideal greenhouse location is well away from trees but protected from prevailing winds, usually by another structure, a fence or a wall.



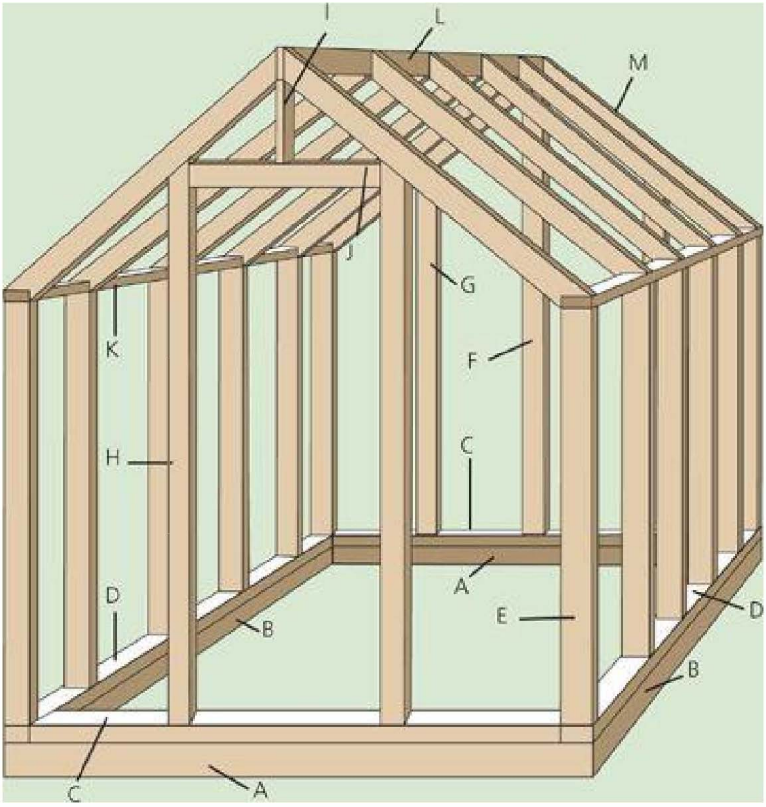
For maximum heat gain, orient your greenhouse so the roof or wall with the most surface area is as close to perpendicular to the sunrays as it can be.

Building a Greenhouse

CUTTING LIST

Key	No.	Part	Dimension	Material
A	2	Base ends	3½ x 3½ x 96"	4 x 4 landscape timber
B	2	Base sides	3½ x 3½ x 113"	4 x 4 landscape timber
C	2	Sole plates end	1½ x 3½ x 89"	2 x 4 pressure treated
D	2	Sole plates side	1½ x 3½ x 120"	2 x 4 pressure treated
E	12	Wall studs side	1½ x 3½ x 57"	2 x 4
F	1	Ridge support	1½ x 3½ x 91"	2 x 4
G	2	Back studs	1½ x 3½ x 76" *	2 x 4
H	2	Door frame sides	1½ x 3½ x 81" *	2 x 4
I	1	Cripple stud	1½ x 3½ x 16"	2 x 4
J	1	Door header	1½ x 3½ x 32"	2 x 4
K	2	Kneewall caps	1½ x 3½ x 120"	2 x 4
L	1	Ridge pole	1½ x 3½ x 120"	2 x 4
M	12	Rafters	1½ x 3½ x 60" *	2 x 4

*Approximate dimension; take actual length and angle measurements on structure before cutting.



TOOLS & MATERIALS

(1) 20 × 50-ft. roll 4 or 6-mil polyethylene sheeting or greenhouse fabric, tack strips
(12) 24"-long pieces of No. 3 rebar
(4) 16-ft. pressure-treated 2 × 4
(2) exterior-rated butt hinges
(1) screw-eye latch
(8) 8" timber screws
Reciprocating saw
Level
Carpenter's square
Drill with a nut driver bit
Eye and ear protection
Metal cutoff saw
Maul or sledgehammer
Speed square

3" deck screws
Exterior panel adhesive
Caulk gun
Hammer
Jigsaw or handsaw
Miter saw
Circular saw
Utility knife
Pneumatic nailer
Scissors
Scrap 2×4
Pencil

How to Build a Gabled Greenhouse



1 Prepare the installation area so it is flat and well drained; then cut the base timbers (4 × 4 landscape timbers) to length. Arrange the timbers so they are flat and level and create a rectangle with square corners. Drive a pair of 8" timber screws at each corner, using a drill/driver with a nut-driver bit.



2 Cut 12 pieces of No. 3 rebar (find it in the concrete supplies section of any building center) to 24" in length to use as spikes for securing the timbers to the ground. A metal cutoff saw or a reciprocating saw with a metal cutting blade can be used to make the cuts. Drill a 3/8" guide hole through each timber near each end and in the middle. Drive a rebar spike at each hole with a maul or sledgehammer until the top is flush with the wood.



3 Cut the plates and studs for the two side walls (called kneewalls). Arrange the parts on a flat surface and assemble the walls by driving three 3" deck screws through the cap and base plates and into the ends of the studs. Make both kneewalls.



4 Set the base plate of each kneewall on the timber base and attach the walls by driving 3" deck screws down through the base plates and into the timbers. For extra holding power, you can apply exterior panel adhesive to the undersides of the plates, but only if you don't plan to relocate the structure later.



5 Cut the ridge support post to length and attach it to the center of one end base plate, forming a T. Cut another post the same length for the front (this will be a temporary post) and attach it to a plate. Fasten both plates to front and back end timbers.



6 Set the ridge pole on top of the posts and check that it is level. Also check that the posts are level and plumb. Attach a 2 × 4 brace to the outer studs of the kneewalls and to the posts to hold them in square relationship. Double-check the pole and posts with the level.



7 Cut a 2 × 4 to about 66" to use as a rafter template. Hold the 2 × 4 against the end of the ridge pole and the top outside corner of a kneewall. Trace along the face of the ridge and the top plate of the wall to mark cutting lines. Cut the rafter and use it as a template for the other rafters on that side of the roof. Create a separate template for the other side of the roof.



8 Mark cutting lines for the rafters using the templates, and cut them all. You'll need to use a jigsaw or handsaw to make the bird's mouth cuts on the rafter ends that rest on the kneewall.



9 Attach the rafters to the ridge pole and the kneewalls with deck screws driven through pilot holes. Try to make the rafters align with the kneewall studs.



10 Mark the positions for the remaining end wall studs on the base plate. At each location, hold a 2 × 4 on end on the base plate and make it level and plumb. Trace a cutting line at the top of the 2 × 4 where it meets the rafter. Cut the studs and install them by driving screws toenail-style.



11 Measure up 78" (or less if you want a shorter door) from the sole plate in the door opening and mark a cutting line on the temporary ridge post. Make a square cut along the line with a circular saw or cordless trim saw (inset). Then cut the door header to fit between the vertical door frame members. Screw the header to the cut end of the ridge post and drive screws through the frame members and into the header.



12 Begin covering the greenhouse with your choice of cover material. (We used 6-mil polyethylene sheeting.) Start at the ends. Cut the sheeting to size and then fasten it by attaching screen retainer strips to wood surfaces at the edges of the area being covered. Tack the sheeting first at the top, then at the sides and finally at the bottom. After the strips are installed (use wire brads), trim the sheeting along the edges of the strips with a utility knife.



13 Attach the sheeting to the outside edge of the base plate on one side. Roll sheeting over the roof and down the other side. Draw it taut and cut it slightly overlong with scissors. Attach retainer strips to the other base plate and then to the outside edges of the corner studs.



14 Make and hang a door. We simply cut a piece of sheet plastic a little bigger than the opening (32") and hung it with retainer strips from the header. Attach a piece of 2 × 4 to the bottom of the door for weight.



15 ***Option:*** **Make a vent** window. First, cut a hole in the roof in one rafter bay and tack the cut edges of the plastic to the faces (not the edges) of the rafters, ridge pole, and wall cap. Then build a frame from 1 × 2 stock that will span from the ridge to the top of the kneewall and extend a couple of inches past the rafters at the side of the opening. Clad the frame with plastic sheeting and attach it to the ridge pole with butt hinges. Install a screw-eye latch to secure it at the bottom. Make and attach props if you wish.


9

Building a Hoophouse

The hoophouse is a popular garden structure for two main reasons: It is cheap to build and easy to build. In many agricultural areas you will see hoophouses snaking across vast fields of seedlings, protecting the delicate plants at their most vulnerable stages. Because they are portable and easy to disassemble, they can be removed when the plants are established and less vulnerable.



A hoophouse is a temporary agricultural structure designed to be low-cost and portable. Also called Quonset houses and tunnel houses, hoophouses provide shelter and shade

(depending on the film you use) and protection from wind and the elements. They will boost heat during the day, but are less efficient than paneled greenhouses for extending the growing season.

While hoophouses are not intended as inexpensive substitutes for real greenhouses, they do serve an important agricultural purpose. And building your own is a fun project that the whole family can enjoy.

The hoophouse shown here is essentially a Quonset-style frame of bent 3/4" PVC tubing draped with sheet plastic. Each semicircular frame is actually made from two 10-ft. lengths of tubing that fit into a plastic fitting at the apex of the curve. PVC tubes tend to stay together simply by friction-fitting into the fittings, so you don't normally need to solvent glue the connections (this is important to the easy-to-disassemble and store feature). If you experience problems with the frame connections separating, try cutting 4" to 6"-long pieces of 1/2" (outside diameter) PVC tubing and inserting them into the tubes and fittings like splines. This will stiffen the connections.



Hoophouse frames can be made from wood instead of PVC plastic. Wood allows you to attach plastic sheeting with retainer strips and staples.

Building & Siting a Hoophouse

The fact that a hoophouse is a temporary structure doesn't give you license to skimp on the construction. When you consider how light the parts are and how many properties sheet plastic shares with boat sails, the importance of securely anchoring your hoophouse becomes obvious. Use long stakes (at least 24") to anchor the tubular frames, and make sure you have plenty of excess sheeting at the sides of the hoophouse so the cover can be held down with ballast. Creating pockets at the ends of the sheeting and inserting scrap lumber is the ballasting technique shown here, but it is also common (especially when building in a field) to weigh down the sheeting by burying the ends in dirt. Only attach the sheeting at the ends of the tubular frame, and where possible, orient the structure so the prevailing winds won't blow through the tunnel.



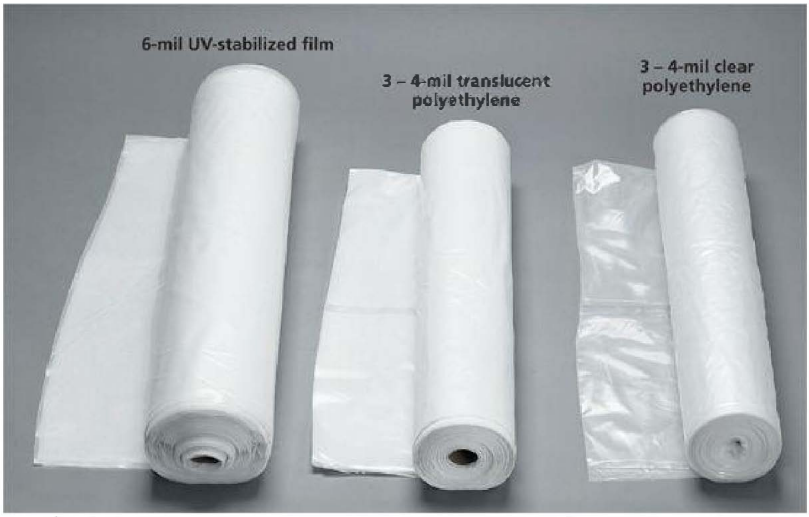
Building a Hoophouse

- Space frame hoops about 3 ft. apart.
- Leave ridge members a fraction of an inch (not more than 1/4") shorter than the span, which will cause the structure to be slightly shorter on top than at the base. This helps stabilize the structure.
- Orient the structure so the wall faces into the prevailing wind rather than the end openings.
- If you are using long-lasting greenhouse fabric for the cover, protect the investment by spray-painting the frame hoops with primer so there is no plastic-to-plastic contact.
- Because hoophouses are temporary structures that are designed to be disassembled or moved regularly, you do not need to include a base.
- The 3/4" PVC pipes used to make the hoop frames are sold in 10 ft. lengths. Two pipes fitted into a tee or cross fitting at the top will result in legs that are 10 ft. apart at the base and a ridge that is roughly 7 ft. tall.
- Clip the hoophouse covers to the end frames. Clips fastened at the intermediate hoops will either fly off or tear the plastic cover in windy conditions.

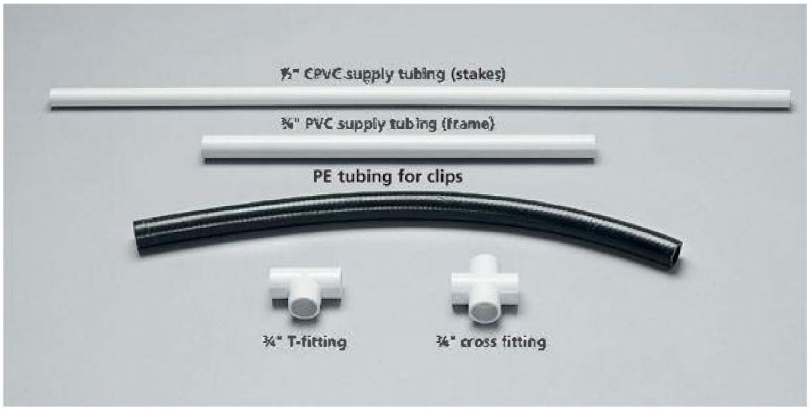




Row tunnels are often used in vegetable gardens to protect sensitive plants in the spring and fall. Plastic or fabric sheeting is draped over a short wire or plastic framework to protect plants at night. During the heat of the day, the sheeting can be drawn back to allow plants direct sunlight.

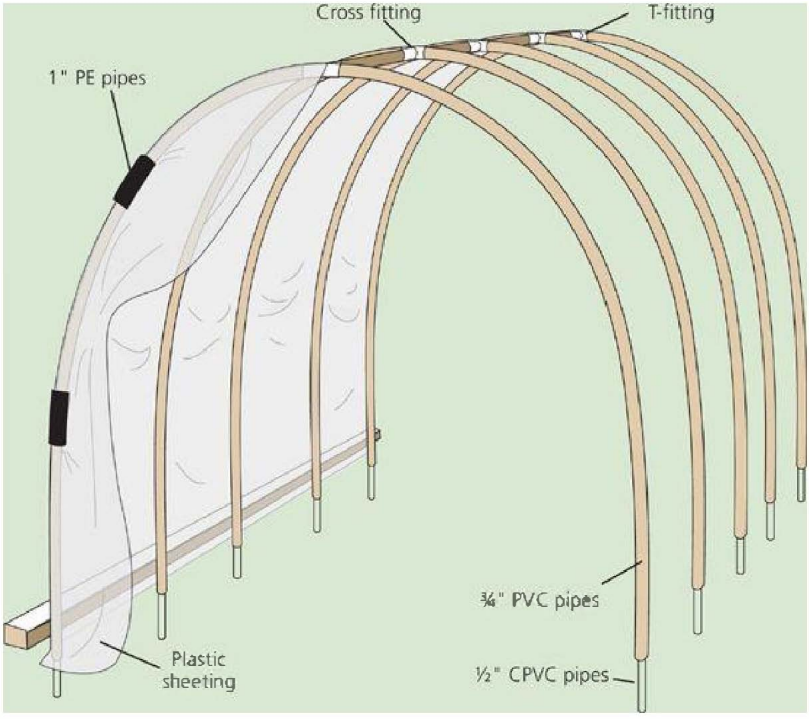


Sheet plastic is an inexpensive material for creating a greenhouse. Obviously, it is less durable than polycarbonate, fiberglass, or glass panels. But UV-stabilized films at least 6-mil thick can be rated to withstand four years or more of exposure. Inexpensive polyethylene sheeting (the kind you find at hardware stores) will hold up for a year or two, but it becomes brittle when exposed to sunlight. Some greenhouse builders prefer to use clear plastic sheeting to maximize the sunlight penetration, but the cloudiness of translucent poly makes it effective for diffusing light and preventing overheating. For the highest quality film coverings, look for film rated for greenhouse and agricultural use.



Plastic tubing and fittings used to build this hoophouse include: Light duty 3/4" PVC tubing for the frame (do not use CPVC—it is too rigid and won't bend properly); 1/2" CPVC supply tubing for the frame stakes (rigidity is good here); Polyethylene (PE) tubing for the cover clips; T-fittings and cross fittings to join the frame members.

Building a Hoophouse

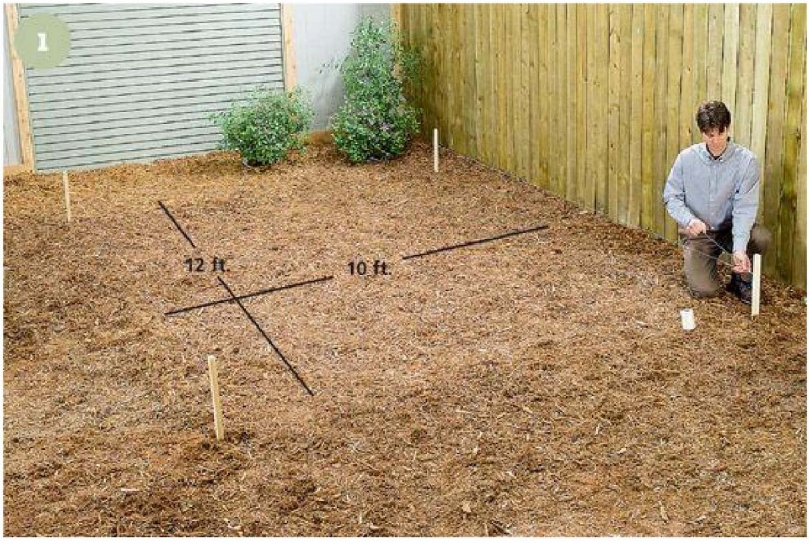


TOOLS AND MATERIALS

(for 10-ft. wide × 15-ft. long project seen here)

(12) 3/4" × 10 ft. PVC pipes
(3) 1/2" × 10 ft. CPVC pipes
(1) 1" × 10 ft. PE pipe (black)
(3) 3/4" PVC cross fittings
(2) 3/4" PVC T-fittings
20 × 16 ft. clear or translucent plastic sheeting
(4) 12-ft. pressure-treated 2 × 4
Stakes
Mason's string
Tape measure
Circular saw
Painters' tape
Mallet
Maul
Stapler
2-1/2" deck screws
Drill

How to Build a Hoophouse



1 Lay out the installation area using stakes and mason's string. Strive for square corners, but keep in mind that these are relatively forgiving structures, so you can miss by a little bit and probably won't be able to notice.



2 Cut a 30"-long stake from 1/2" CPVC supply tubing for each leg of each hoop frame. Measure out from the corners of the layout and attach a piece of high-visibility tape on the string at 3-ft. intervals; then drive a stake at each location. When the stake is fully driven, 10" should be above ground and 20" below.


3



3 Join the two legs for each frame hoop with a fitting. Use a tee fitting for the end hoop frames and a cross fitting for the intermediate hoop frames. No priming or solvent gluing is necessary. (The friction-fit should be sufficient, but it helps if you tap on the end of the fitting with a mallet to seat it.)



4 Slip the open end of one hoop-frame leg over a corner stake so the pipe is flush against the ground. Then bend the pipes so you can fit the other leg end over the stake at the opposite corner. If you experience problems with the pipes pulling out of the top fitting, simply tape the joints temporarily until the structure frame is completed.



5 Continue adding hoop frames until you reach the other end of the structure. Wait until all the hoop frames are in place before you begin installing the ridge poles. Make sure the cross fittings on the intermediate hoop frames are aligned correctly to accept the ridge poles.



6 Add the ridge-pole sections between the hoop frames. Pound on the end of each new section as you install it to seat it fully into the fitting. Install all of the poles.



7 Cut four pieces of pressure-treated 2 × 4 to the length of the hoophouse (12 ft. as shown). Cut the roof cover material to size. (We used 6-mil polyethylene sheeting.) It should be several inches longer than is necessary in each direction. Tack the cover material at one end of the 2 × 4 and then continue tacking it as you work your way toward the end. Make sure the material stays taut and crease-free as you go.



8 Lay a second 2 × 4 the same length as the first over the tacked plastic so the ends and edges of the 2 × 4s are flush. Drive a 2-1/2" deck screw through the top 2 × 4 and into the lower one every 24" or so, sandwiching the cover material between the boards. Lay the assembly next to one edge of the hoophouse and pull the free end of the material over the tops of the frames.



9 On the other side of the structure, extend the cover material all the way down so it is taut and then position another 2 × 4 underneath the fabric where it meets the ground. Staple the plastic and then sandwich it with a final 2 × 4.



10 Make clips to secure the roof cover material from a 12"-long section of hose or soft tubing. Here, 1"-dia., thin-walled PE supply tubing is slit longitudinally and then slipped over the material to clip it to the end frames. Use at least six clips per end. Do not clip at the intermediate hoop frames.



11 ***Option:*** Make doors by clipping a piece of cover material to each end. (It's best to do this before attaching the main cover.) Then cut a slit down the center of the end material. You can tie or tape the door material to the sides when you want it open and weigh down the pieces with a board or brick to keep the door shut. This solution is low-tech but effective.


10

Preserving Your Bounty

Preserving garden produce does not need to be an overwhelming task, but it is important to think through your strategy before you get started. To understand how to preserve food, it's important first to understand why fresh fruits and vegetables spoil and decay. There are two main culprits: First, external agents, such as bacteria and mold, break down and consume fresh food. Second, naturally occurring enzymes—the very same ones that cause fruits and veggies to ripen—are also responsible for their decay. Canning, freezing, drying, and cold storage (along with salt-curing/smoking, and making fruit preserves) are all ways to slow down or halt these processes while retaining (to varying degrees) nutrition and taste.



Canning is one of the most popular forms of food preservation. The process is reliable and can be applied to a wide variety of vegetables.



Drying Produce

An electric food dehydrator is a fast, effective tool for drying fruit and vegetables. Because the produce is dried quickly in a closed environment, the process is very sanitary and yields consistent, predictable results.



Each method for preserving food has its strengths and weaknesses. It's important to weigh these carefully and decide which preservation method is the best fit for your garden's needs and your lifestyle.

Choosing the Best Preservation Method

Produce	Canning (See page 82)	Freezing (See page 81)	Dehydration (See page 84)	Live Storage (See page 92)
Apples	✔		✔	✔
Asparagus	✔	✔		
Beans (green)	✔	✔		
Beans (lima)	✔	✔	✔	
Beets	✔			✔
Broccoli		✔	✔	
Brussel Sprouts			✔	✔
Cabbage				✔
Carrots	✔	✔		✔
Cauliflower		✔		
Celery				✔
Cherries	✔		✔	
Corn	✔	✔		
Cucumbers	✔ (with pickling)			
Onions				✔
Pears	✔		✔	✔
Peaches	✔	✔	✔	
Peas	✔	✔	✔	
Peppers (green)		✔	✔	
Peppers (hot)			✔	
Potatoes	✔			✔
Pumpkin	✔			✔
Radishes				✔
Spinach	✔	✔		
Squash (summer)	✔	✔	✔	
Squash (winter)	✔			✔
Strawberries		✔	✔	
Tomatoes	✔	✔	✔	

Canning. Canning changes the taste of foods and results in some vitamin loss, but is versatile and can be used to preserve many different kinds of foods for lengthy periods of time.

Cellaring. Live storage preserves produce with minimal effect on taste or nutritional value, but it only makes sense for a few foodstuffs. The fruits and vegetables that can be cellared for limited periods of time require a storage environment that must be carefully regulated.

Freezing and drying. Freezing and drying both retain a high percentage of vitamins and have a minimum effect on flavor, but only certain foods can be preserved with these methods and careful preparation and regulation is extremely important. Freezing can damage the cellular structure of fruits and vegetables, causing an unpleasant mushiness that makes them suitable only for dices and purees. Drying also changes the nature of fruits and vegetables; for example, drying fruits causes the caloric value to double or triple as the starches convert to sugars during the process.

Preservation by Freezing

Freezing is the best way to preserve delicate vegetables. It's also a quick process that is perfectly suited to smaller batches of food. In this process, foods should be blanched to stabilize nutrients and texture, cooled to preserve color, packaged in an airtight container, and frozen as quickly as possible. Frozen food, if properly packaged and contained within a temperature-consistent frozen environment, can be preserved for as long as a year. Of course, the longer you wait to eat your food, the more it will break down, which results in a loss of taste and freshness. Food can also absorb ambient flavors in the freezer environment, negatively affecting the taste.



Freezer Tip

Fill empty food containers, such as old milk jugs, with water and place them in the freezer around your frozen foods. With a freezer full of these homemade “ice packs,” your freezer will stay colder much longer in the event of a power outage and the appliance will work at maximum efficiency, consuming less energy.



Generally, the colder you keep your freezer, the longer your frozen food will stay tasting fresh. For best results, use a chest freezer instead of the little box above your refrigerator. Although chest freezers are an investment, they maintain colder temperatures more consistently than your refrigerator's freezer. The ideal temperature for your chest freezer is –5°F, and it should be no warmer than 0°. Even a few degrees above zero will cut the freezer life of your food in half.

Preservation by Home Canning

Canning is a traditional method for preserving produce. It is not difficult to master, but it's important to pace yourself. Try not to plan more than one canning project a day to keep the work manageable and enjoyable. Also, make sure you are familiar with how to use your canning equipment safely, and that you have a reliable recipe to reference for each food you plan to can. Every fruit and vegetable has a different acidity and requires slightly different accommodations in the canning process.

To get started with canning, there are two main tools to become familiar with: a water bath canner and a pressure canner. Foods with high acidity, such as fruits (including tomatoes), can be canned in a boiling water bath. Less acidic foods, including most vegetables, and any combination of high- and low-acidity foods must be processed using a pressure canner. Water bath and pressure canners are NOT interchangeable, largely because they reach vastly different temperatures during their processes. Always make sure the canner you use is appropriate for the produce you're preserving and follow your canning recipe exactly.



Beware of Botulism

Home canning is perfectly safe if all instructions are followed exactly. However, if canning procedures are not followed, harmful bacteria can fester while your produce sits in your pantry waiting to be used. The best known of these bacteria is *clostridium botulinum*, which produces a potent toxin that is odorless, colorless, and fatal to humans in small amounts. Cases of botulism poisoning are rare, but to avoid this toxic substance, it's important to always follow the home canning recipe and procedures exactly. And if in doubt, throw it out.

Other tools you'll need include canning jars, measuring cups, a long-handled spoon, a funnel, a jar lifter, and cooking pots. Canning jars typically have two-piece metal lids: The metal band can be reused whereas the disc part of the lid cannot form an adequate seal more than once, and should be discarded after one use. Always inspect jars carefully before beginning: Check for nicks on the rim or cracks anywhere in the jar. Discard or repurpose any imperfect jars as they will not be able to form an adequate seal.



Make sure you understand how to use your home canning equipment before you get started. Take time to read through the manual that comes with your canner, and make sure you use the right type of home canner for the fruit or vegetable you're planning to preserve. A pressure canner and sealable canning jars with two-piece lids are shown here.

The Home Canning Process

1. Wash and heat the jars. Immerse jars in simmering water for at least 10 minutes or steam them for 15 minutes. Heat jar lids (just the disc part) in a small saucepan of water for at least 10 minutes. Keep lids hot, removing one at a time as needed.
2. Pack food in the jars. Different packing methods are used for different types of produce. In cold packing, raw food is placed in a hot jar and then hot liquid is poured over the food to fill the jar. In hot packing, foods are precooked and poured into a hot jar immediately after removing them from the heat source.
3. Watch your headspace. Headspace is the amount of space between the rim of the jar and the top of the food and is very important to making sure that your canning jars seal correctly. Always follow your recipe's directions—generally it's best to leave about 1" of headspace for low-acid foods, 1/2" for acidic foods, and 1/4" for pickles, relishes, jellies, and juices.
4. Remove air bubbles. Insert a nonmetal spatula or chopstick and agitate the food to remove all air bubbles.
5. Place the lid. Clean the jar rim, then set a hot disc on the jar rim and screw on the band until you meet the initial point of resistance and no further.
6. Heat. Place jars on the rack in the water bath or pressure canner and process immediately. Follow the directions for your canner.
7. Cool. Allow the jars to cool slowly after processing—cooling too quickly can cause breakage. Typically, jars should cool along with the water they're submerged in, but follow the directions for your canner. Do not tighten the lids unless they are very loose. As the jars cool, you'll hear them "pop" when they are properly sealed. If the jar does not seal, refrigerate and eat within the next couple days.
8. Clean and label. After cooling and confirming the jar's seal, wash the outside of the jar and label with the content and date.

9. Store. Store in a cool, dark cupboard or pantry. If a jar loses its seal during storage (i.e., if the metal disc does not pop when you remove it), the food inside is not safe to eat. Dump it on the compost bin and try a different jar.

Canned Food Safety Quiz

Ask yourself the following ten questions to determine if your home-canned food is safe to eat:

1. Is the food in the jar covered with liquid and fully packed?
2. Has proper headspace been maintained?
3. Is the food free from moving air bubbles?
4. Does the jar have a tight seal?
5. Is the jar free from seepage and oozing from under the lid?
6. Has the food maintained a uniform color?
7. Is the liquid clear (not cloudy) and free of sediment?
8. Did the jar open with a clear "pop" or "hiss" and without any liquid spurts?
9. After opening, was the food free of any unusual odors?
10. Is the food and underside of the lid free of any cottonlike growths?

If you can answer "yes" to all of the questions, your food is probably safe. That said—if you have even a small suspicion that a jar of food is spoiled—dump it in the compost bin. Never, under any circumstances, taste food from a jar you suspect may have spoiled or lost its seal. Botulism spores have no odor, cannot be seen by our eyes, and can be fatal, even in small doses.



Sun drying in the open air is a traditional method for preserving fish, tomatoes, and peppers. Although it can be a very useful technique if specific environmental criteria are met (see next page), sun-drying generally is not a practical option for preserving garden produce in your backyard.

Preservation by Drying

There are many advantages to dehydrating produce from your garden. Most dehydration methods require very little extra energy other than that already provided by the sun. Also, dehydrated foods, if prepared correctly, retain much of their original beauty and nutritional value. And since foods lose so much of their mass during the dehydration process, they do not require much space to store through the winter and can easily be rehydrated to taste delicious months after the harvest.

Dehydration is a food preservation technique that has been used for centuries all around the world. Removing 80 to 90 percent of the moisture in food, it halts the growth of spoilage bacteria and makes long-term storage possible. Warm, dry air moving over the exposed surface of the food pieces will absorb moisture from the food and carry it away. The higher the temperature of the air, the more moisture it will absorb, and the greater the air movement, the faster the moisture will be carried away.

Temperature matters a lot in food drying—air at a temperature of 82° will carry away twice as much moisture as air at 62°. This process also concentrates natural sugars in the foods. The faster the food is dried, the higher its vitamin content will be and the less its chance of contamination by mold. Extremely high temperatures, however, will cause the outside surface or skin of the food to shrivel too quickly, trapping moisture that may cause spoilage from the inside out. Exposure to sunlight also speeds up the drying process, but can destroy some vitamins in foods.

Often, foods should be treated before drying. Blanching as you would for freezing (see page 81) is recommended for just about any vegetable (notable exceptions being onions and mushrooms). Some fruit and vegetables dry best if cut into pieces, whereas others should be left whole. Coating the produce can help preserve the bright color of skins. Many dipping mixtures may be used (consult a recipe book), but lemon juice is probably the most common.

In the following pages, we'll discuss a few different food dehydration options—both outdoor and indoor, and show you how to build drying trays and an outdoor solar dryer.



Apples are a favorite fruit for drying because they retain so much of their flavor. Look for sweet varieties like Fuji. Core them and cut them into 1/8"-thick rings or slices for drying. Peeling is optional. Dip the apples in lemon juice immediately after cutting or peeling to prevent browning.



Load food onto a drying tray and place it in a sunny, warm spot. Place the tray on wood blocks to promote air circulation from all sides. Cover the food with cheesecloth to prevent insects from reaching the food. Prop the cheesecloth above the food with blocks and toothpicks and weigh down all edges with scrap lumber.

Drying Produce on Trays

If you live in an area with clean air, a dry climate, and consistently sunny weather around harvest-time, you can have some success sun-drying food. The chief ingredients you'll need are time and the right weather: 85 to 100° and low to moderate humidity for several consecutive days. You'll also need a place to set your food so it receives good air circulation but is not exposed to pollution from vehicles.

- Use either stainless-steel or a nonmetallic material for your food-drying screens. Metal screen materials could be coated with chemicals that contaminate food.
- Spread your food on the trays in a single layer so the pieces do not touch one another.
- Protect your food from insects with cheesecloth—drape the cloth over wooden blocks to keep it from touching the food, and weigh down all of its edges with scrap lumber so it doesn't blow away.
- Place your trays on top of blocks at least six inches tall to promote air circulation on all sides.

Drying food outdoors will likely take at least two to three days, and perhaps longer. At dusk each day, bring the trays indoors. Cool nights can restore moisture, which not only slows down the drying process, it can also cause mold to grow. Better yet, if you have an indoor drying method—such as a food dehydrator or one of the other methods on page 90—it's a good idea to keep the drying process going at night if you can. The food will dry much faster and this lessens the chance of mold growth.

Solar Dryer

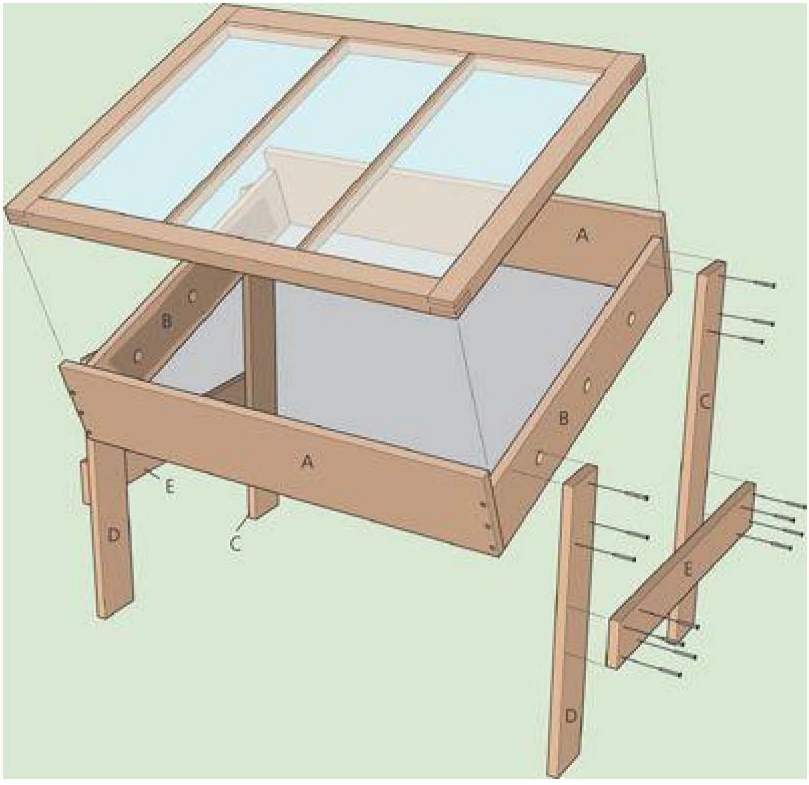
A solar dryer is a drying tool that makes it possible to air-dry produce even when conditions are less than ideal. This dryer is easy to make, lightweight, and is space efficient. The dryer makes a great addition to your self-sufficient home, allowing you to use your outdoor space for more than gardening. The dryer, which is made of cedar or pine, utilizes a salvaged window for a cover. But you will have to adjust the dimensions given here for the size window that you find. The key to successful solar drying is to check the dryer frequently to make sure that it stays in the sun. If the air becomes cool and damp, the food will become a haven for bacteria. In a sunny area, your produce will dry in a couple days. Add a thermometer to the inside of your dryer box, and check on the temperature frequently—it should stay between 95 and 145°F. You may choose to dry any number of different vegetables and fruits in the dryer, such as:

- Tomatoes
- Peppers
- Apples
- Squash
- Bananas



An old glass window sash gets new life as the heat–trapping cover of this solar dryer.

Building a Solar Dryer



CUTTING LIST

Key	Part	No.	Dimension	Material
A	Front/back	2	¾ x 7½ x 34¾"	Cedar
B	Side	2	¾ x 5½ x 27⅛"	Cedar
C	Leg (tall)	2	¾ x 3½ x 30"	Cedar
D	Leg (short)	2	¾ x 3½ x 22"	Cedar
E	Brace	2	¾ x 3½ x 24"	Cedar

Insect Mesh—fiberglass 28-7/8 × 34-3/4"

TOOLS & MATERIALS

1" spade bit
Circular saw
(1) 1 × 8" × 8ft.
(1) 1 × 6" × 8ft.
Eye protection
(2) 1 × 4" × 8ft.
Stapler
1-1/4" deck screws
Drill
Staples
Insect mesh
Window sash
1-1/2" galv. finish nails
Brad nails

How to Build a Solar Dryer



1 Assemble the box. Attach the wider boards for the frame by driving screws through the faces of the 1 × 8" boards into the ends of the 1 × 6" boards. There will be a difference in height between these pairs of boards so that the window sash can sit flush in the recess created.



2 Install the mesh. Staple the screen to the frame. Then tack the retainer strips over the screen to the frame with 3-4 brad nails per side. Trim off the excess mesh.



3 Build the stand. Attach each 24" board to a 30" board (in the back) and a 22" board (in the front) with 1-1/4" deck screws. Then attach the finished posts to the frame with three 1-1/4" deck screws in each post.



4 Drill three 1" holes for ventilation in each 1 × 6" board equally spaced along the length of the board, leaving 5" of room on each end for the posts. Staple leftover insect mesh behind the ventilation holes on the inside of the frame.



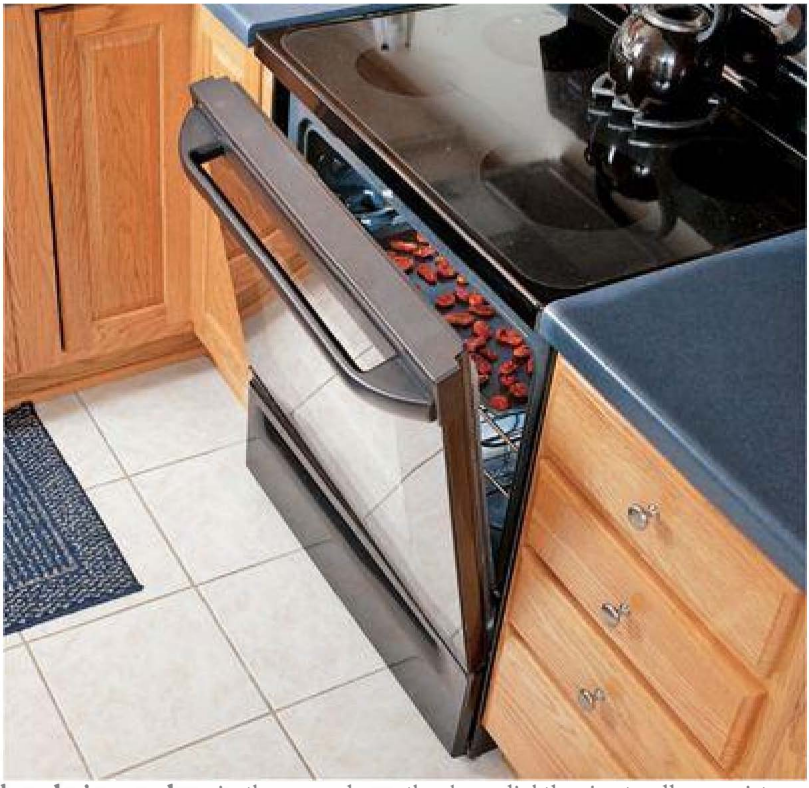
5 Finish the project by sliding the window sash into place.

Drying Produce Indoors

Drying vegetables indoors allows you to carefully control the drying conditions and offers more protection from insects and changes in weather. An electric food dehydrator appliance is the simplest choice for indoor drying. If you don't have a dehydrator, the next best option is in or around your oven, although any hot, dry area will do—possibly even your attic or the area around a heater or cookstove.

If you plan to dry produce in your oven, keep in mind that the process typically takes eight to twelve hours. Preheat your oven and check that it can maintain a temperature of 130 to 145° for at least an hour—some ovens have a difficult time holding low temperatures like this, and going over 150° can be disastrous for drying produce. Wash and prepare the food, then spread food in single layers on baking sheets, making sure the pieces do not touch. Place the sheets directly on the oven racks, leaving at least 4" above and below for air circulation. Also, make sure to leave the oven door slightly ajar to allow moisture to escape. Rearrange the trays and shift food from time to time to ensure even drying.

You may also dry food on your oven's range by creating a chafing dish. To create a chafing dish on your range, you'll need two baking trays: The first must be large enough to cover all burners and hold a 3"-deep reservoir of water. The second tray should fit on top of the first. Fill the bottom tray with water and set all burners to low heat. Throughout the process, refill the reservoir periodically to make sure food doesn't burn, and move/turn food as necessary to ensure even drying. Place a fan nearby to keep the air moving around the room, which will help carry moisture away from the food more quickly.



When drying produce in the oven, leave the door slightly ajar to allow moisture to escape, and carefully monitor temperature to ensure the oven doesn't heat to over 150°.



An electric produce dehydrator can dry large quantities of fruits or vegetables in a sanitary environment. The stackable trays allow you to match the appliance's drying capacity to your needs each time you use it.

How Long Does Dehydration Take?

Drying times vary considerably—from a few hours to many days, depending on the climate, humidity, drying method, and the moisture content of the food you're dehydrating. Generally, fruit is done drying if it appears leathery and tough and no moisture can be squeezed from it. Vegetables should be so brittle and crisp that they rattle on the tray. To check for completed dehydration, you can also check the food's weight before and after the process. If the food has lost half its weight, it is two-thirds dry, so you should continue to dry for half the time you've already dried.

To double-check that your food is dry, place it in a wide-rimmed, open-topped bowl covered with cheesecloth fastened with a rubber band. Place the bowl in a dry place, and keep the food in the bowl for about a week. Stir it a couple times a day—if any moisture or condensation appears, you should continue to dehydrate.



Enjoying Your Dehydrated Food

Many foods are delicious and ready to eat in their dried forms—especially tomatoes and berries. But dried food can also be rehydrated before eating. To rehydrate food, pour boiling water over it in a ratio of 1-1/2 cups of water to 1 cup of dried food, then let the food soak until all the water has been absorbed. You may also steam fruit or vegetables until rehydrated. Rehydrated vegetables should be cooked before eating, whereas rehydrated fruits are acceptable to eat without cooking after rehydration.

Pasteurization and Storage

Regardless of the drying method used, food should be pasteurized before storage to ensure that there are no insect eggs or spoilage microorganisms present. To pasteurize, preheat the oven to 175°. Spread dried food 1" deep on trays and bake in the oven for 10 to 15 minutes. Dried food is best stored in clean glass jars or plastic bags in a cool, dry place. Never store dried food in metal containers and carefully monitor the humidity of the storage environment. Containers should have tight-fitting lids and should be stored in a dark, dry place with an air temperature below 60°.





Use your oven to heat fruits and vegetables to a high enough temperature to kill bacteria and related contaminants. About 15 minutes at 175°F will suffice for most produce, provided it is not in layers over 1" deep. Oven-drying takes about a half day at 140° or so.


11

Setting Up a Root Cellar

Cool storage areas such as cellars can be outfitted to keep produce fresh for the table throughout the long winter months. A wide variety of foods will stay fresh and delicious if stored in the right conditions—a space that is damp and cold, but not freezing. Typically, 32 to 40 degrees Fahrenheit is ideal for a root cellar environment. This type of food storage is entirely dependent on thermal mass and the natural cooling of outdoor air during the winter, and this isn't vulnerable to power outages. Traditionally, root cellars are an underground space built under or near the home, insulated by the ground and vented so cold air can flow in and warm air out in the fall. In the winter, the vents are then closed and the cellar maintains a cold—but not freezing—temperature, thanks to the earth's insulation.



A root cellar doesn't actually need to be underground, although they often are. Any cool, dark area will do.

Of course a walk-in root cellar built like this is the most reliable solution, but you can still practice cold storage without an external walk-in root cellar. The best systems are adapted to each home and climate, and can be as simple as a deep hole in the yard that is carefully covered, to a homemade basement cold room, like the one described on page 95.

How to Store Produce in a Root Cellar

Vegetable	Will Store For...	Special Instructions
Apples	5 to 8 months	Apples give off a gas that causes root vegetables to sprout or spoil, so store them in separate spaces. Apples also like to be moist—and store well in a barrel lined with paper or sawdust.
Cabbage and Cauliflower	Cabbage—3 to 4 months Cauliflower—1 month Chinese Cabbage—2 months	Store only sound, solid heads. Place the heads in plastic bags that have a few holes to let excess moisture escape. Remove roots and outer leaves.
Carrots and Parsnips	4 to 6 months	Snip off the leaves just above the crown. Store in covered containers filled with moist sand or moss.
Celery	2 to 3 months	Harvest just before heavy frost. Leave the roots and soil attached and set in moist sand in a shallow container on the cellar floor. The sand should be only deep enough to cover the roots and must be kept slightly moist. Cover or store in the dark.
Hot Peppers	6 months	Air dry and store in a cool, well-ventilated room.
Pears	3 months	Pack in loose paper in crates or barrels.
Potatoes and other Root Vegetables	Beets—3 months Potatoes—5 to 8 months Turnips—4 to 5 months	Cut off the tops about ½" above the crown. Store bedded in vented plastic bags or covered crates filled with damp sphagnum moss or sand. Keep out of light. Note that potatoes like to be stored a little warmer—around 40°.
Pumpkins and Squash	Pumpkins—3 months Squash—6 months	Leave a part of the stem on each pumpkin or squash. Pumpkins and squash thrive in a slightly warmer space—between 55 and 60°. Keep pumpkins and squash dry—a humid space will cause them to deteriorate.
Onions and Garlic	Onions—8 months Garlic—7 months	Pull when tops fall over and begin to dry. When tops are completely dry, cut them off 1" from the bulbs. Cure for another week or two before placing in storage. Onions and garlic are best kept dry and stored in mesh bags or crates.

How to Set Up a Basement Root Cellar

Modern basements are typically too warm for long-term winter storage, but you can create an indoor version of a root cellar by walling off and insulating a basement corner and adding vents to the outside to let you regulate the flow of cold outside air into the insulated room. Your goal is to create a small room that is well insulated and will remain near freezing throughout the winter months. Cellar rooms are typically quite humid, so be sure to choose insulation materials that will hold up well in a moist environment.

First, choose a location for your cellar that is as far as possible from your furnace, and near a basement window, if possible. The window is a great place to install a vent—simply remove the window glass, replace it with insulated plywood, and run the vent through a hole in the wood. (You could also run a vent through a basement wall—as you would for a clothes dryer.) Choose a northeast or northwest corner location if you can. The more masonry surface in your root cellar room, the better—masonry walls provide thermal insulation to help create the ideal temperature inside. If a northeast or northwest corner won't work for your basement, choose the corner with the highest outdoor soil height.



Store only mature, high-quality vegetables in a root cellar: small, cut, bruised, or broken vegetables will not store well and should be eaten right away. Check on your stored foods frequently to see how they're doing—if the vegetables begin to grow, the cellar is too warm. If they freeze, the cellar is too cold. If the skin starts to look dry or shriveled, the space is too dry. Remove decaying vegetables immediately to prevent rot from spreading to the rest of your food.

To Store Carrots: Cut off greens and wrap them in small groups of newspaper. Bury paper packages in dry sand.

Building a Root Cellar



TOOLS & MATERIALS

Chalk
Eye protection
Ear protection
Construction adhesive
Concrete nails
Powder-actuated nail gun
Drill
Level
Deck screws
Circulating saw
Insect mesh
Sheet plastic vapor barrier
Foam insulation
Stapler
Stick up light
Fiberglass butt insulation
Paneling or drywall
Steel garage service door
Weather stripping
Masking tape
4d finish nails
Glue
Wood screws
Framing square
Sander

How to Add a Root Cellar to a Basement



1 Outline the root cellar wall locations on your basement floor with chalk or a chalkline. Don't get too skimpy—the foot-print should be at least 4 × 6 ft. to make the project worthwhile.



2 Build 2 × 4 stud walls with a framed rough opening for a door. Anchor the sole plates for the walls (use pressure-treated lumber) to the floor with construction adhesive and concrete nails driven into predrilled holes (or use a powder-actuated nail gun).



3 Use a level to adjust the walls until they are plumb and then secure the cap plates of the framed walls to the joists above with deck screws. If the cap plate on the wall that's parallel to the joists does not align with a joist, you'll need to install wood blocking between the joists to have a nailing surface for the cap plate.



4 Insulate the interior walls to keep the ambient basement heat out of the root cellar. Rigid foam insulation is a great choice for root cellar walls, since it is more resistant to mold and deterioration from moisture than fiberglass batts.



5 Staple a sheet-plastic vapor barrier to the basement side of the walls where condensation is likely to form.



6 Also insulate the ceiling. Line the joist cavities above the root cellar with sheet plastic before you install the insulation to create a vapor barrier there (the vapor barrier always goes on the warm side of the insulation). Use faced fiberglass batt insulation, or use unfaced fiberglass and install a ceiling covering such as paneling.



7 Install a wall covering, such as paneling or drywall, over the vapor barrier on the basement side (required for fire resistance). You may cover the wall on the root-cellar side if you wish—there is little point in doing it for aesthetic reasons, but the wallcovering will protect the insulation from damage.



8 Hang the door. A steel garage service door with a foam core is durable and well insulated. Be sure to install weatherstripping around the door to create a seal that minimizes heat transfer.



9 Remove the basement window sash, if your cellar area has a window. (If not, install a vent in the rim joist—find information on installing a dryer vent for guidance.) Keep the window stop molding in the jambs intact if you can.



10 Make a ventilation insert panel to replace the window. The panel should have an outflow vent with a manually operated damper so you can regulate the temperature by letting warmer air escape. It should also have an intake vent with ductwork that helps direct cold air down to floor level. On the exterior side, cover the vent openings with insect mesh to prevent rodents and insects from gaining access to your cellar.

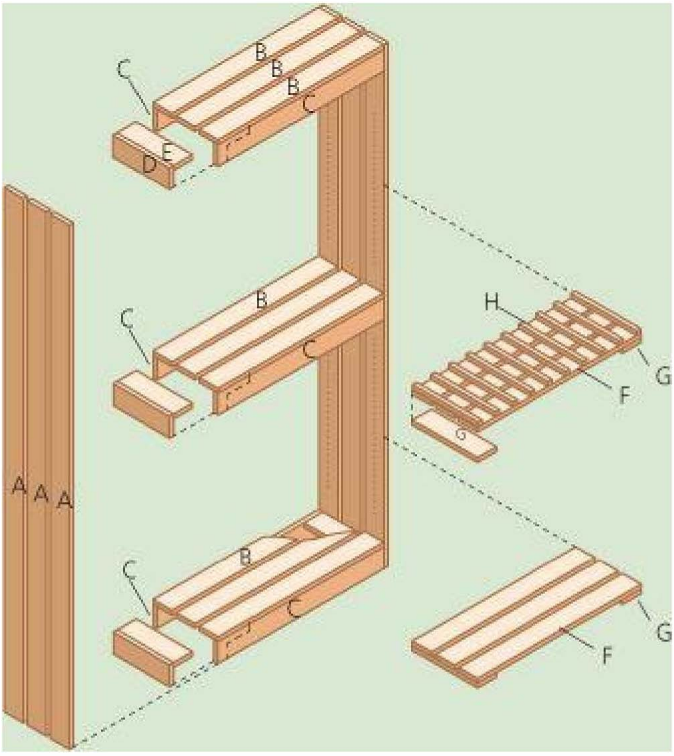


11 Install the ventilation panel insert in the window frame by nailing or screwing it up against the stop molding. Caulk around the edge to prevent insects from getting in. Paint or cover the outside of the panel to weatherproof it.



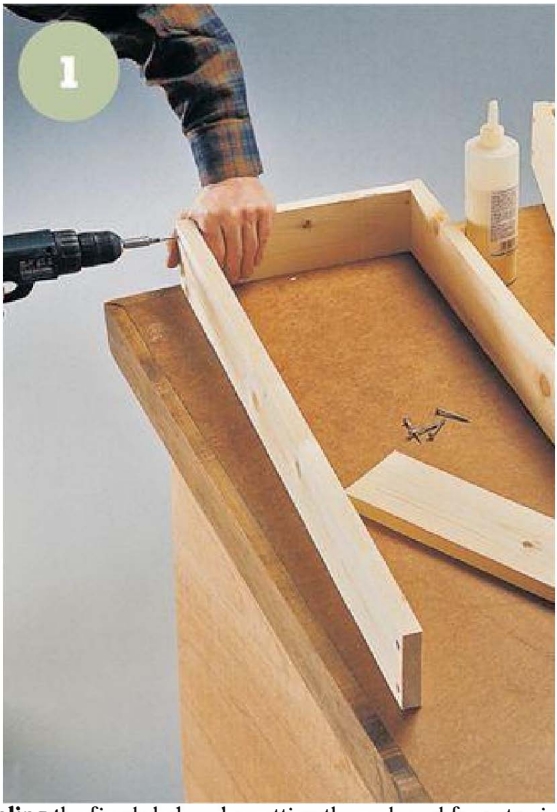
12 Provide lighting. If you do not want to install a new, hardwired light and switch (this should be done before walls are covered if you do it), install a stick-up light that operates on battery power. A model with LED bulbs will run for months of intermittent use without a battery change. Add racks and storage features (see next page).

How to Build a Root Cellar Shelf



CUTTING MATERIALS

Key	Part	Dimension
A	(6) Side slat	¾ × 3½ × 84" pine
B	(9) Fixed-shelf slat	¾ × 3½ × 30½" pine
C	(6) Fixed-shelf face	¾ × 3½ × 30½" pine
D	(6) Fixed-shelf end	¾ × 3½ × 10½" pine
E	(6) Fixed-shelf stretcher	¾ × 3½ × 10½" pine
F	(6) Adjustable shelf slat	¾ × 3½ × 30⅜" pine
G	(4) Adjustable shelf stretcher	¾ × 3½ × 12" pine
H	(10) Bottle-shelf cleat	¾ × ¾ × 12" pine



1 Begin assembling the fixed shelves by cutting the ends and faces to size, and then joining them with glue and counterbored screws. Check with a framing square to make sure the frames you're assembling are square.



2 Add the stretchers to the tops of the fixed shelf frames. In addition to strengthening the fixed shelf units, the stretchers provide nailing or screwing surfaces for attaching the shelf slats.



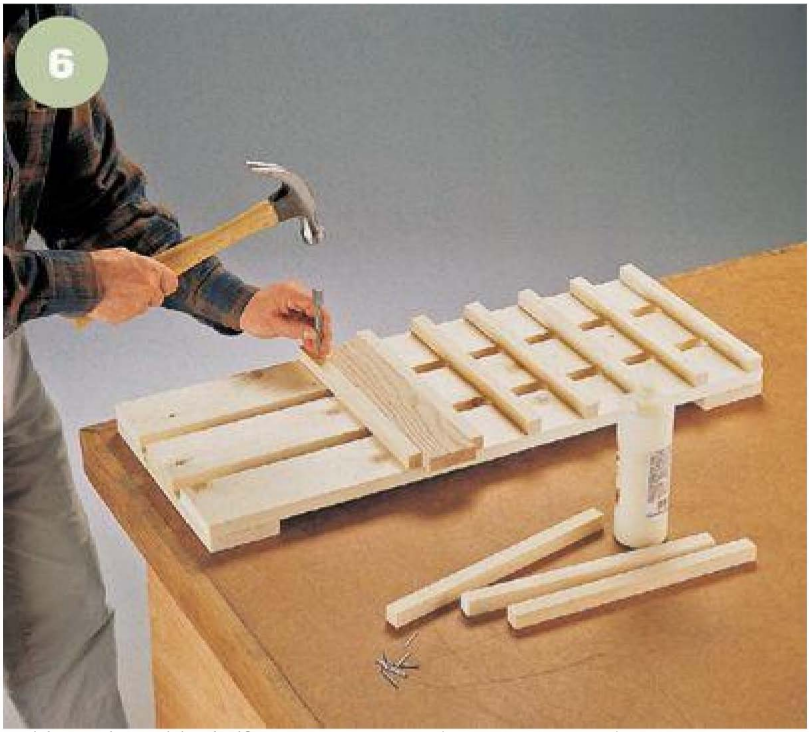
3 Cut the fixed-shelf slats to length, sand them, and attach them to the fixed shelf frames by driving 1-1/4" screws up through counterbored pilot holes in the stretchers and into the bottom of the slats. Keep your spacing even and make sure the slats do not overhang the frame ends.



4 Cut the side slats to length, sand them, and attach them to the outside of the fixed shelf units with glue and counterbored wood screws. Make sure the spacing (3/4" between slats) is correct and that all joints are square.



5 Drill adjustable shelf peg holes in the side slats. To ensure good results, make a drilling template from a piece of perforated hardboard. Use a drill bit the same diameter as your shelf pins, and drill the holes 1/2" deep. Use masking tape as a drilling depth gauge.



6 Build an adjustable shelf to support a bottle (wine, for instance) rack, using a 2-1/2" wide spacer to set the distances separating the shelf cleats. Attach the cleats to the shelf with glue and 4d finish nails. Make the other adjustable shelf.



7 Insert shelf pins and install the adjustable shelves. Fill screw-hole counterbores with wood plugs, trim flush, and sand. Finish the shelf as desired. Because it is for indoor use, you may leave it unfinished for a rustic look if you prefer.


12

Raising Animals

Raising small farm animals can be a challenge and it is a serious responsibility, but once you've taken the plunge the rewards can be so great that it is very difficult to go back. You'll find a number of reasons why chickens and other small animals can be a great addition to the self-sufficient home: In addition to the companionship and fun they provide, they can be a great source of wool, milk, meat, and eggs (depending on species of course).



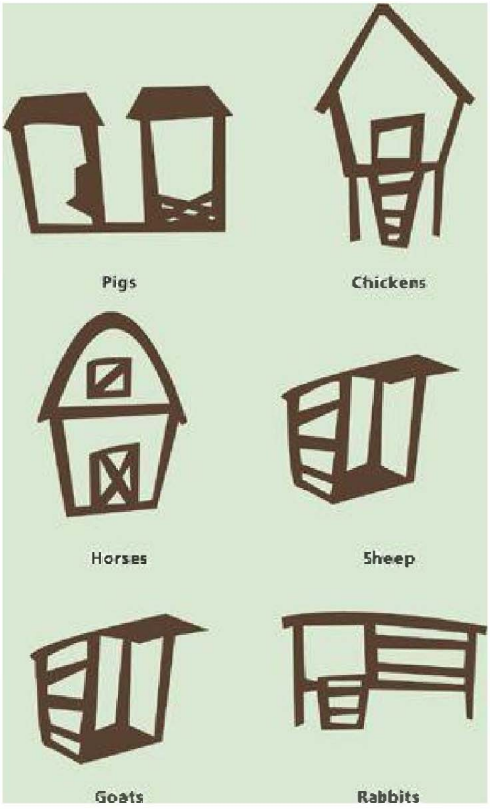
Chickens are probably the most popular farm animal when it comes to fitting in to a city lifestyle (see Building a Chicken Ark, page 115). In recent years, many larger cities have relaxed their restrictions on keeping animals, so if you've been turned down in the past it might be worth checking again.

If your animal experience is limited to walking your dog and emptying the cat box, it's a good idea for you to start small in your livestock adventure. Chickens are an excellent indoctrination —they require little space, are easy to care for, and provide the reward of fresh eggs and/or lean, free range meat. As you consider which animals you'd like to purchase, consider how different species will fit your land, temperament, experience, and time allowance. If you're a beginner, wait until you grow more confident before adopting notoriously flighty sheep, or a conniving goat that will try to outsmart you.

Also, it's important to select animals that will be comfortable on your property. How hot or cold is the region where you live? While you can make accommodations by choosing the right shelter for your animal, some extreme climates simply are not suitable for every animal. Before you purchase livestock, contact local veterinarians and find out whether they will treat the species you plan to buy. If you cannot find a vet in your area who will treat the llama you're planning to purchase, find out how far you'll have to drive to reach someone who will, and weigh this into your decision. Also, think through the logistics of how you will transport your animal and the time it will take to reach the vet.

Lastly, check with your municipality to find out what the limitations are when it comes to owning livestock. If you live in the city, you may need to request permission from your neighbors to house animals, and some species may not be allowed at all. There may also be setback requirements that apply to animal housing—take these into consideration when planning out the site for your animals' home.

Match Your Shelter to Your Animal



Every species has different needs regarding the type of shelter they require to grow up healthfully. Research the specific needs of your animal before you build a new shelter or convert an existing one.

Animal Infrastructure

Before you introduce animals to your backyard, prepare your property for their arrival. Think of it as building a nest—consider where the animals will sleep, what they will eat, and where they will roam and play. Build fencing and shelter, provide a water source and feed area, and find a dependable veterinarian who can administer immunizations. You'll also need to determine whether your property is zoned for the type of animals you want to raise, what limits apply in terms of animal shelter setbacks, grazing requirements, and whether or not you'll need to apply for licenses, permits, and community permission.

A barn is not necessary for every species, though most animals require some type of shelter for protection from the elements and, perhaps, for sleeping. The type of roof you put over animals' heads depends largely on where you live. In the chilly north, animals will require a more sturdy, draft-resistant abode than in the hot and dry southwest. Build your shelter to suit your climate —in cold climates, your shelter should be designed to keep animals warm, and in warm climates, designed to keep animals cool. Tailor your shelter to meet your animals' needs. For example, pigs require separate space for eating and sleeping, whereas sheep and goats just need a dry shelter to protect them from the elements.

Fencing

The species of animals you keep will determine the kind of fencing you should build to protect them. Goats are especially tricky and will gnaw and break through fencing. Your best bet for goats is a woven-wire fence with posts of steel or wood, with added protection from two strands of barbed wire, one at the top and one at the bottom of the fence. Pigs like to outsmart fencing systems, hence the phrase "hog-tight fence." Build a fence of woven wire or permanent wood at least three feet tall.

Some species really do not care to try to get out, but you do need a fence to protect them from predators. A fence tall enough to keep out predators in your area—typically five feet or so—will work for these animals.



A good, strong fence is the best insurance you can obtain for goats, hogs, and other animals with a strong sense of wanderlust.

Pigs

Pigs are personable and intelligent. They also offer a well-rounded learning experience for new animal owners: lessons on the importance of feed mix, daily pigpen cleaning to prevent disease (and smell!), and good old-fashioned recycling. Their composted byproduct is rich fertilizer for your garden.

Pigs don't require a great deal of land, but they do need a dry, draft-free shelter to protect them from the elements. Be sure to prepare this space before bringing home your new pets. You can dedicate a portion of an existing building, such as a barn or shelter, or construct a simple outbuilding. Ideally, the floor should be concrete and sloped for optimal drainage during daily hose-outs. A dirt floor is also fine as long as you replace hay bedding daily.

Pigs also require a separate sleeping and feeding area. A five foot by five foot square sleeping area will accommodate two pigs. The feed area should be twice this size and contain the feed trough, a watering system, and a hose connection. This serves the double purpose of instant water refills for thirsty pigs and accessibility to your number one pigpen-cleaning tool.

Contain your pigs with a secure fence of woven wire or permanent board (see page 108). The fence should be about three feet tall. Pigs are immensely social animals and love the spotlight, so be sure to spend time with them to help them grow healthy and happy.



Pigs love attention and are infinitely curious. Be sure to build a strong fence around your pigpen to keep your pigs contained.

Goats

Goats are mischievous class clowns with boundless energy and a lovable nature. They are a great source of both milk and meat, and do not require a vast amount of resources, food, or shelter. They are ruminants that enjoy munching twigs and leafy brush—but if you will be raising goats for their milk, feed them with a forage of hay and grain to preserve their milk's taste. Some goat breeds are also a great source of fibers for fabrics, such as mohair and angora. You'll want to watch these breeds' diets carefully, as their coat will be affected by their diet. Feed them only quality pasture or hay, along with plenty of fresh, clean water.

There's no need to build a fancy house for goats, as they fare well in pretty much any dry, draft-free quarters. Goats are prone to respiratory problems triggered by a moist environment, so avoid heating that can result in condensation. House goats in a three-sided barn, shed, or a shared barn with other animals. It's a good idea to invest your savings on shelter in quality fencing, however. Woven-wire pasture fencing is ideal, and additional strands of barbed or electrical wire will discourage curious goats from escaping.

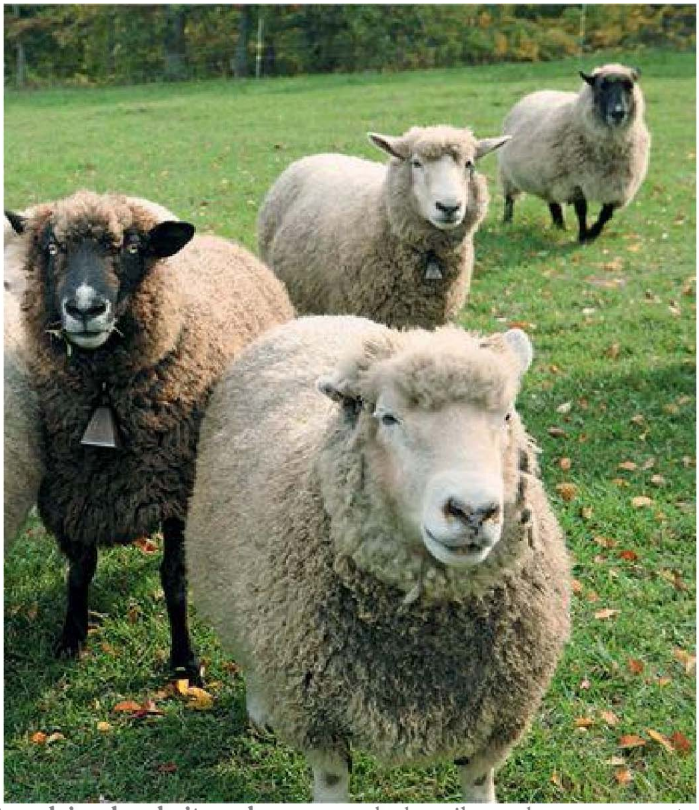


Goats are high-spirited, lovable, and mischievous animals that love to play. Watch out, though—your goats will try to outsmart you (or your fence!). Goats are a great source of milk, wool, and meat.

Sheep

Sheep are affectionate animals raised most often for their high-quality wool that can be spun into yarn and made into warm textiles. Choose a breed of sheep with a wool density that correlates with the weather where you live—in the north, choose sheep with extra "lining" in their coats; in temperate or arid climates, sheep with fine wool and hair prosper.

When purchasing sheep, look for healthy feet. From the front view, legs and hooves should align, as opposed to being knock-kneed, splayfooted, or pigeon-toed. Check the animal's bite, and be sure there are no udder lumps or skin lesions. Sheep do need to be shorn every spring before the weather heats up, so take good care of your sheep's wool and sell or spin it after it is collected. To care for your sheep (and their wool), make sure they have good nutrition, well-managed pastures, and vaccinations. Sheep need a sturdy fence and some type of shelter, though existing buildings on your land will suit them just fine. They are easy targets for predators, such as coyotes, so make certain your fence is secure.

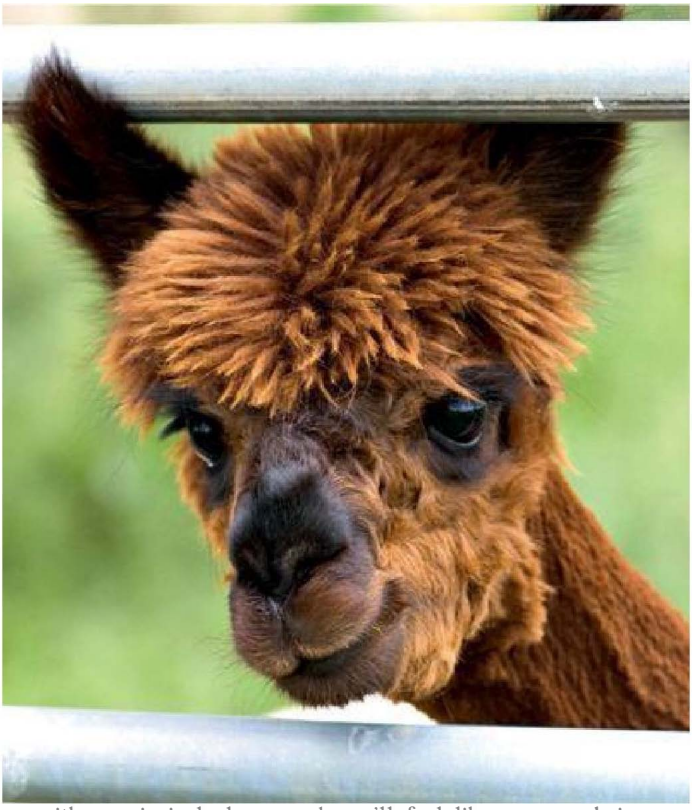


Sheep travel in close-knit packs, are spooked easily, and are an easy target for predators, so make sure your sheep are protected by a secure fence.

Alpacas

Alpacas are smaller cousins to llamas and camels and are an approachable, friendly species, which makes them appealing to landowners who want to begin caring for animals. They won't challenge your fencing or trample your pasture. They also require little feed—about a third less than a sheep. Alpacas grow thick coats that are five times warmer than wool and far more durable. Yarn spinners covet alpaca fiber, homeowners admire these loving pets, and investors appreciate the potential returns these valuable creatures promise.

Fencing you'll build for alpacas is designed more to keep predators out than to keep alpacas in. These animals are not ambitious escape artists—not nearly as tricky as goats. But predators can represent a threat to sensitive alpacas, so it's a good idea to install strong perimeter fencing that is at least five feet tall. Separate females and males with fencing. Females and their newborns must have separate quarters from the rest of the pack, but do not completely isolate them from the group. A three-sided shelter is adequate for alpacas, which are accustomed to rugged, cold climates. Heat is more of a concern for these animals, and their insulating fiber coats are no help in keeping them cool in summer. A misting system or fans in the alpaca shelter will prevent them from overheating.



Lock eyes with a quizzical alpaca and you'll feel like you are being probed for information. Alpacas are gentle animals that are easy to care for and produce soft, extremely warm coats that can be shorn and sold to textile makers.



Vinyl fencing is durable and virtually maintenance free. However, damaged pieces are expensive to replace and materials can cost up to twice as much as a traditional wood fence. For these reasons, most landowners use vinyl to enclose smaller areas.

Fences

Fencing plays a critical role in controlling animals, keeping out predators, sectioning off pastures, drawing property lines, and adding aesthetic appeal to properties. Your fencing needs will vary depending on the size of your lot and what type of animals call your land home (pigs, chickens, horses). Hobby farms will require functional fences, but if you live on a country estate, the reasons for your fence may be purely aesthetic. There are materials and designs that accommodate both goals.

Fence Materials

Progress in fencing is evident in the type of materials available, synthetics like PVC, and the improved life expectancy of good old standards like wood and wire, which can be treated with a vinyl coating. High-tensile wire fencing can last up to 50 years. But the more traditional types, such as split-rail, Virginia rail, and post-and-rail, will always have their place.

Before choosing fencing material, ask yourself the following: How large is the area to be fenced? What is the purpose of your fence? Will you install it yourself or hire a professional? How much are you willing to spend?



Utilitarian by design, yet pleasing to the eye, the post and board fence evokes the uncomplicated beauty and peacefulness of rolling countryside. The same effect holds true in suburban settings.

Post & Board Fences

Post and board fences include an endless variety of simple designs in which widely spaced square or round posts support several horizontal boards. This type of fence has been around since the early 1700s, when it began to be praised for its efficient use of lumber and land and its refined appearance. The post and board is still a great design today. Even in a contemporary suburban setting, a classic, white three- or four-board fence evokes the stately elegance of a horse farm or the welcoming, down-home feel of a farmhouse fence bordering a country lane.

Another desirable quality of post and board fencing is its ease in conforming to slopes and rolling ground. In fact, it often looks best when the fence rises and dips with ground contours. Of course, you can also build the fence so it's level across the top by trimming the posts along a level line. Traditional agricultural versions of post and board fences typically include three to five boards spaced evenly apart or as needed to contain livestock. If you like the look of widely spaced boards but need a more complete barrier for pets, cover the back side of the fence with galvanized wire fencing, which is relatively unnoticeable behind the bold lines of the fence boards. You can also use the basic post and board structure to create any number of custom designs. The fence styles shown in the following pages are just a sampling of what you can build using the basic construction technique for post and board fences.

TOOLS & MATERIALS

Tools and materials for setting posts
Mason’s string
Line level
Circular saw
Speed square
Clamps
Drill
4 × 4 posts
Finishing materials
Bar clamps
Chisel
Primer paint or stain
3" stainless-steel screws
Post levels
Combination square
Eye and ear protection
Lumber (1 × 6, 1 × 4, 2 × 6, 1 × 3)
Deck screws (2", 2-1/2", 3-1/2")
8d galvanized nails
Scrap 2 × 4
Work gloves
Pencil



A low post and board fence, like traditional picket fencing, is both decorative and functional, creating a modest enclosure without blocking views. The same basic fence made taller and with tighter board spacing becomes an attractive privacy screen or security fence.

How to Build a Post & Board Fence



1 Set the posts in concrete, following the desired spacing. Laying out the posts at 96" on center allows for efficient use of lumber. For smaller boards, such as 1 × 4s and smaller, set posts closer together for better rigidity.



2 Trim and shape the posts with a circular saw. For a contoured fence, measure up from the ground and mark the post height according to your plan (post height shown here is 36"). For a level fence, mark the post heights with a level string. If desired, cut a 45° chamfer on the post tops using a speed square to ensure straight cuts. Prime and paint (or stain and seal) the posts.



3 Mark the board locations by measuring down from the top of each post and making a mark representing the top edge of each board. Use a speed square to draw a line across the front faces of the posts at each height mark. Mark the post centers on alternate posts using a combination square or speed square and pencil. For strength, it's best to stagger the boards so that butted end joints occur at every other post. The centerlines represent the location of each butted joint.



4 Install 1 × 6 boards. Measure and mark each board for length, and then cut it to size. Clamp the board to the posts, following the height and center marks. Drill pilot holes and fasten each board end with three 2-1/2" deck screws or 8d galvanized box nails. Use three fasteners where long boards pass over posts as well.

Virginia Rail Fence

The Virginia rail fence—also called a worm, snake, or zigzag fence—was actually considered the national fence by the U.S. Department of Agriculture prior to the advent of wire fences in the late 1800s. All states with farmland cleared from forests had them in abundance.

The simplest fences were built with an extreme zigzag and didn't require posts. To save on lumber and land, farmers began straightening the fences and burying pairs of posts at the rail junctures.

A variation in design that emerged with entirely straight lines is called a Kentucky rail fence.

Feel free to accommodate the overlapping rail fence we build here to suit your tastes and needs. Increase the zigzag to climb rolling ground, decrease it to stretch the fence out. All lapped rail fences should be made from rot-resistant wood like cedar, locust, or cyprus. For the most authentic-looking fence, try to find split rather than sawn logs. For longevity, raise the bottom rail off the ground with stones. Posts may eventually rot below ground, but the inherently stable zigzag form should keep the fence standing until you can replace them.

TOOLS & MATERIALS

Tools & materials for laying out the fence line
Tools & materials for setting posts
Chainsaw or reciprocating saw
Long-handled maul
Bolt cutters
Hatchet
Large screwdriver
Pliers
Clothesline rope
Work gloves
9-gauge galvanized wire



The Virginia Rail Fence exhibits a very familiar style to anyone who has spent much time in countryside that was cleared and farmed in the 18th and 19th centuries. Since nails were scarce, these zigzagging post- and-rail fences were popular because they are held together with only wire or rope.

How to Build a Virginia Rail Fence



1 Create layout lines in the fence installation area for each section. Mark post locations and a main fence line with additional layout lines parallel to the fence line. The total distance between the outer lines (here, 24") equals the amount of switchback on each rail section. Dig your post holes and install your posts.



2 Bind your post pairs together at the top and place spacers on the ground for the bottom rail. Insert the bottom rail between the posts, resting on the spacers.



3 Install split fence rails in alternating courses at each post pair, keeping the overhangs even.

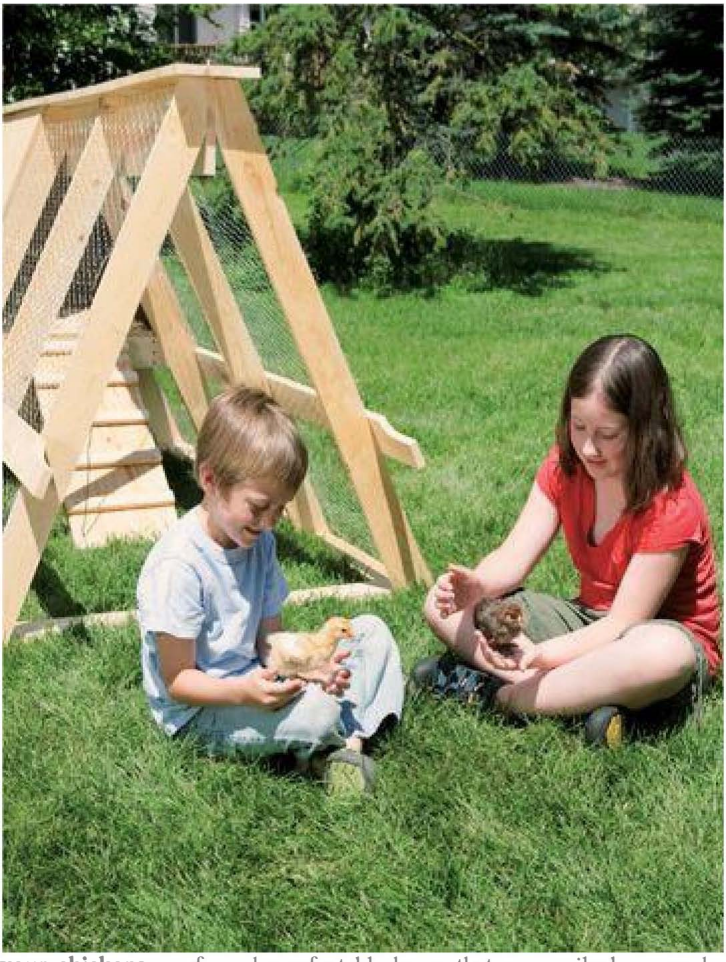


4 Bind the tops of the posts together permanently with 9-gauge galvanized wire to hold the rails in position. Tighten the wire by twisting with a screwdriver blade as if you were tightening a tourniquet.

13

Building a Chicken Ark

Chickens adapt more easily to life on a small urban homestead than other farm animals. Consequently, raising urban chickens has grown in popularity in recent years. In fact, many municipalities have relaxed their restrictions and requirements when it comes to tending a small number of hens. It's worth noting that the same latitude has not been given to roosters—typically, you must file a document with the consent of all your neighbors before the city will let you keep a loud winged alarm clock in your yard.



Build your chickens a safe and comfortable home that can easily be moved around your yard or garden. This type of portable coop, known as a chicken ark or a chicken tractor, should keep your birds safe from the elements and from predators.

Chickens can live comfortably in many different types of environments, from small urban backyards to roomy farms and ranches. They have a lot to offer the self-sufficient homeowner: high-quality meat, farm-fresh eggs, new chicks, and even nitrogen-rich garden fertilizer. Chickens do require a safe place to live, especially during the night. Usually, this takes the form of a chicken coop.

A chicken coop that can be easily moved around your yard or garden offers the added benefit of distributing natural fertilizer while the chickens feast on bugs and weeds in your yard. Some gardeners even design mobile coops to cap their raised beds so the birds can be moved around to fertilize the soil and prepare it for planting in the spring. The portable coop that is built on the following pages contains both a roost with laying nests and a protected scratching area. It is large enough to accommodate four to six full size hens, is attractive enough to find a home in any urban, suburban, or estate yard, and is complete with all the essential components of a coop: space for roosting, nesting boxes for laying eggs, and easy access for the bird owner to refill food and water, clean the coop and replace bedding, and to collect eggs.

NOTE: This chicken ark is made from untreated pine, so its direct exposure to the elements should be limited. Although the preserving chemicals in modern treated lumber are not considered toxic, they should not be ingested directly—and chickens tend to peck at and eat their habitats. Even woods with natural rot resistance, such as cedar, often contain chemical compounds that can cause irritation if ingested.

Approvals

The first step to starting your own chicken coop is to get permission from your local municipality. Many cities and towns allow homeowners to keep hens, but no roosters. Typically, there is also a limit on the number of hens you can keep, and the distance your coop must be located from your neighbors' windows. Check the regulations in your municipality as you develop your chicken ranching plan. It's also important to talk with your neighbors to seek out their consent, even if their written permission is not required.

Getting Started

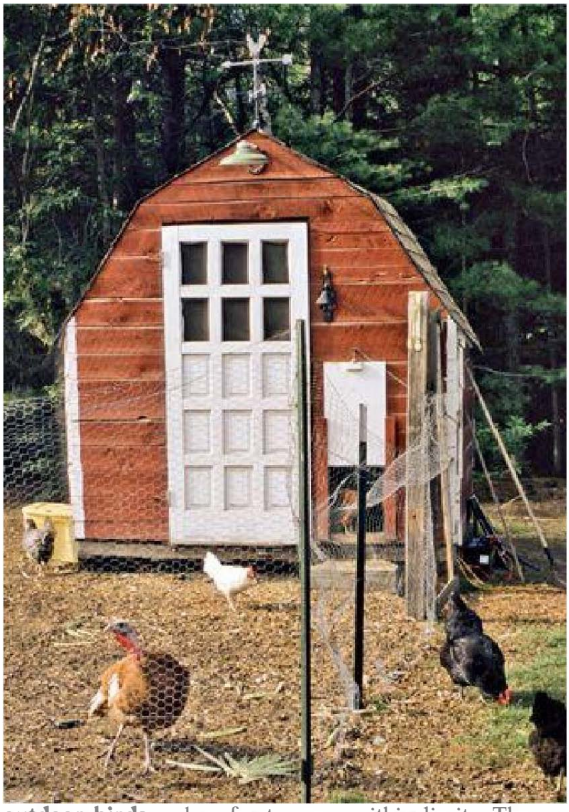
If you plan to raise chickens for their eggs, it's best to purchase pullets (chickens less than a year old) that have already been vaccinated and have just begun laying eggs. Pullets do not require a special brood environment, like chicks, but you should carefully monitor their light exposure and heat when they're young. Keep your pullets in the coop for a week or so to help them get accustomed to their new home.

When they are old enough, allow your hens out of the coop during the day to peck and wander around a larger enclosed area, such as a small yard surrounded by a fence. Hens will not wander far. They love to dine on the bugs and weeds in your yard, and will produce a greater yield of healthier eggs if allowed to move around freely. At night, make sure all your hens are safely locked in to the coop to sleep.

Collecting Eggs

Collecting eggs from a brooding hen requires a careful hand and sound timing. Expect a good pecking if you reach into the nest while mother is awake. The best time to gently remove eggs from the nest is in the morning or during the night, when hens roost. This is also the best time to pick up a hen and move her, because she won't argue while she's sleeping. Eggs may be brown, white, or sometimes even light blue or speckled–depending on the breed of your chicken. No matter the appearance, what's inside will taste the same.

Gather eggs twice a day, and even more frequently during temperature extremes when eggs are vulnerable. The longer they sit in the nest, the more likely eggs are to suffer shell damage. After gathering, pat the eggs clean with a dry cloth. If they are noticeably dirty, wash them with warm water. Place clean, dry eggs in a carton and refrigerate.



Chickens are outdoor birds and prefer to roam within limits. They are natural pest-controllers and will stay healthiest if allowed to move about for a portion of every day.

Chicken Breeds

So, why do you want chickens?

Perhaps you dream of eggs with thick, sturdy sunshine yolks that are unbeatable for baking (and perhaps for selling at a farmers' market stand). Maybe you want to dress the dinner table with a fresh bird. Not sure? If you want both eggs and meat, you're safe with a dual-purpose breed such as the barred Plymouth Rock.

Next, consider the size flock you will need to fulfill your goals. This depends on land availability and how much produce you wish to gain. In other words, if volume of eggs or meat matters, then you increase your "production line." If your reason for raising chickens is to enjoy the company of a low-maintenance feathered pet—the meat and eggs are just a bonus—then a flock of three or four hens and possibly a rooster will get you started.

Layers

While all chickens produce eggs, laying breeds are more efficient at the job than other breeds; in short, layers lay more eggs. You can expect about 250 eggs per year or more if your layer is more ambitious than most. Laying hens tend to be high-strung, however, and while they lay many eggs, they show little interest in raising chicks. You may reconsider laying breeds if you want your hens to raise the next generation. Layers simply aren't interested—but they'll keep seconds coming to the breakfast table.

Meat Breeds

These chickens are classified based on size when butchered. Game hens weigh 1 to 3 pounds (.5 to 1.4 kg), broilers (also called fryers) range from 4 to 5 pounds (1.8 to 2.3 kg), and roasters are usually 7 pounds (3.2 kg) or slightly more. You'll find cross-breeds ideal for the backyard, including broiler-roaster hybrids like the Cornish hen or the New Hampshire.

Dual-Purpose Breeds

Larger than layers but more productive (in the egg department) than meat breeds, dual-purpose breeds are the happy medium.

Hens will sit on eggs until they hatch, so you can raise the next generation. There are many chickens that fall into this variety, and their temperaments vary. Many dual-purpose breeds are also heritage breeds, meaning they are no longer bred in mass for industry. They like to forage for worms and bugs, are known for disease resistance, and, essentially, are the endangered species of the chicken world.



Chickens raised for meat usually are purchased from a hatchery or a feed store when just a day or two old. Raising them to broiler weight (4 to 5 pounds) takes six to eight weeks. During this time they will consume around 15 pounds of feed.

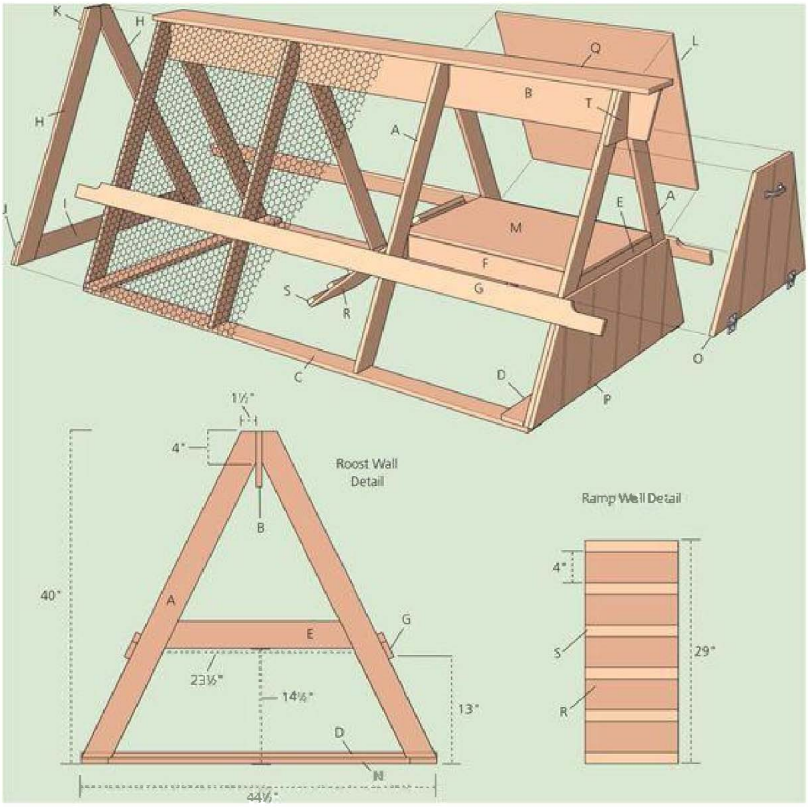


Ornamental chickens often make good pets. They enjoy human companionship. And they are a fun and visual addition to the yard!



Chickens do well in cold weather as long as they have a sheltered, insulated roosting area and their water supply is not allowed to freeze.

Building a Chicken Ark



CUTTING LIST

Key	Part	Dimension	Pcs.	Material
A	Rafters	¾ x 3½ x 46"	8	1 x 4 pine
B	Ridge pole	¾ x 7¼ x 86"	1	1 x 8 pine
C	Base plate	¾ x 3½ x 81"	2	1 x 4 pine
D	Spreader	¾ x 3½ x 44½"	2	1 x 4 pine
E	Roost beam	¾ x 3½ x 23½"	2	1 x 4 pine
F	Roost joist	¾ x 3½ x 26"	2	1 x 4 pine
G	Handle	¾ x 3½ x 96"	2	1 x 4 pine
H	Door stile	¾ x 3½ x 47¼"	2	1 x 4 pine
I	Door rail	¾ x 3½ x 36¾"	1	1 x 4 pine
J	Door bottom brace	¾ x 3½ x 44½"	1	1 x 4 pine
K	Door gusset	¾ x 7¼ x 8¼"	1	1 x 8 pine
L	Roost side	½ x 27¾ x 29"	2	Siding panel
M	Roost floor	½ x 20 x 27½"	1	Siding panel
N	Base filler	¾ x 3½ x 36¾"	1	1 x 4 pine
O	Roost door	½ x 19½ x 29½"	1	Siding panel
P	End wall	½ x 44⅝ x 16¼"	1	Siding panel
Q	Ridge board	¾ x 3½ x 88"	1	1 x 4 pine
R	Ramp	½ x 12 x 29"	1	Siding panel
S	Ramp battens	¾ x 1½ x 12"	6	1 x 2 pine
T	Roost Door Filler	½ x 1½ x 4"	2	Sliding

TOOLS & MATERIALS

Circular saw
Jigsaw
Speed square
Tape measure
Power miter saw
Drill
Galvanized wood screws (1-1/4", 2", 3-1/2")
Galvanized common nails
Hammer
Eye protection
Sander
Spacers

Galvanized finish nails
Pneumatic narrow crown stapler
Poultry netting (chicken wire)
Galvanized U-nails
Aviation snips
Pliers
Galvanized butt hinges (6)
Galvanized T-hinges (2)
Galvanized latches (4)
Door Handle

How to Build a Chicken Ark



1 Make the eight rafters by laying out one rafter according to the diagram on page 118. Use this rafter as a template for marking and cutting the remaining rafters from 1 × 4 pine.



2 Cut an 8-ft. 1 × 8 to 86" to make the ridge pole. Cut at a bevel of 10 to 15° for a decorative tail cut at the roost end. Then, attach the rafters on one side of the ridge pole with 2" deck screws driven through the ridge pole and into the rafters. The rafters should be spaced according to the diagram (26" apart in the field area).



3 Attach the rafters on the opposite side of the ridge pole by driving 3-1/2" deck screws through counterbored pilot holes in the rafter tops and into the ridge pole.



4 Attach the base plates to the bottom ends of the rafters with deck screws. The outside edges of the base plates should be flush with the outside edges of the rafters. Then, attach the spreader at each end of the framework. Make sure the rafter legs are spaced consistently.



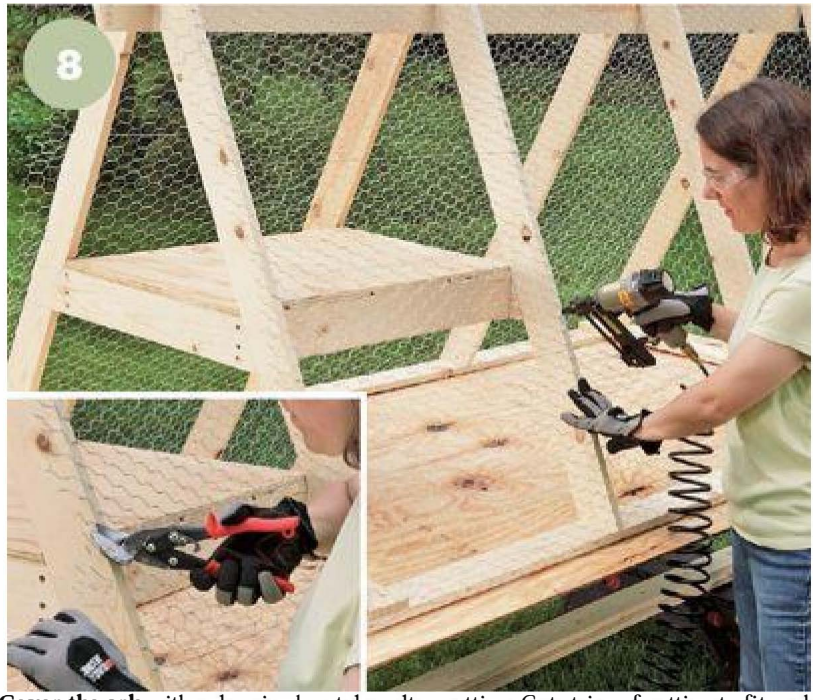
5 Attach the roost beams between the legs of the outside rafters. The bottoms of the beams should be 14-1/2 " up from the bottom of the ark. **TIP:** Before cutting the beams to size, hold the workpiece against the rafters to make sure it will fit. Attach the beams with 3-1/2" deck screws predrilled and driven up toenail style through the bottom edges of the beams and into the rafters.



6 Attach the roost joist boards between the beam boards, flush against the inside edges of the rafters. Drive three 2" deck screws per joint.



7 Make the floor board for the roost. Cut the panel to size and then test the fit. Install the floor with pneumatic staples or screws driven into the beams and joists.



8 Cover the ark with galvanized metal poultry netting. Cut strips of netting to fit each side and then staple the netting with a pneumatic stapler and 7/8" narrow crown staples (otherwise, hand nail it with U-nails: A staple gun is inadequate for this job.) Trim the ends of the poultry netting (inset).



9 Cut the profiles onto the ends of the handles. Make a cardboard template of the profile and then trace the profile onto each end. Cut with a jigsaw and then sand the cuts and edges smooth.



10 Attach the carrying handles for the ark with 2" deck screws driven into pilot holes. The bottoms of the handles should be about 13" up from the bottom of the ark—make sure they are parallel to the base. Take care when drilling the pilot holes to keep them centered in the edges of the rafters. Make sure the handle end overhangs are equal and that the profiles are pointing upward.



11 Attach the roost side panels to the ark frame with pneumatic nails or staples or with 1-1/4" deck screws.



12 Install the end wall and the hinged roost door. The wall is affixed permanently with screws or staples. The door should be hinged from below. Install snap latches to the roost door fillers to secure the door in place when it is raised.



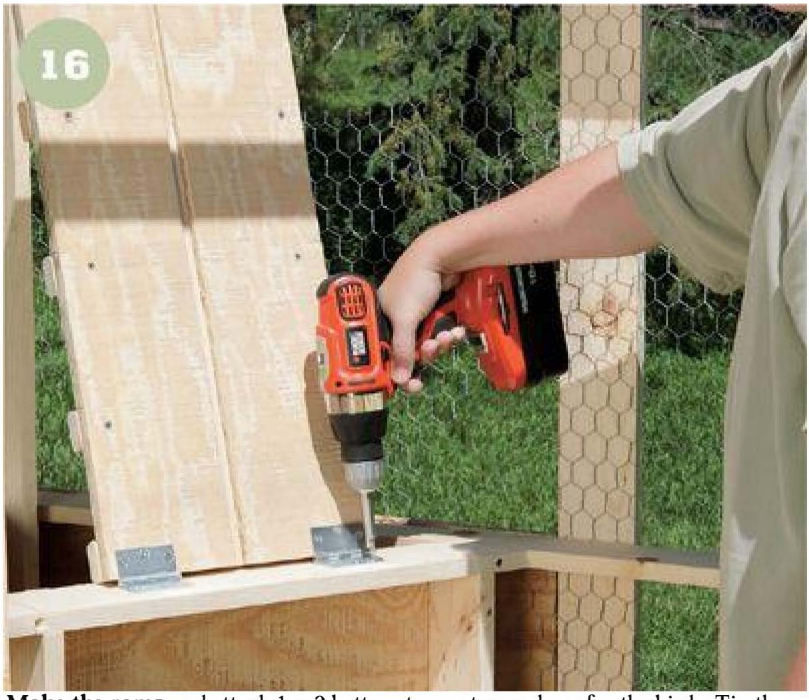
13 Make the frame for the ark door that fits against the open end of the ark. Rather than hinges, use latch hardware to hold the door in place. Begin by making the triangular door frame. Then, attach poultry netting to the exterior face of the door.



14 Complete the ark door by cutting and attaching the door brace and the door gusset and then securing the door against the end of the ark frame with latch hardware. Consider adding a utility handle to the gusset for ease of door handling.



15 Cut a 1 × 4 ridge board to span from the top of the ark door gusset to the beveled end of the ridge pole at the opposite end of the ark. Center the ridge board side to side and nail it to the ridge pole to cover the gaps.



16 Make the ramp and attach 1 × 2 battens to create purchase for the birds. Tip the coop up on end, then attach the ramp to one side of the roost floor with butt hinges. **TIP:** Drill a hole in the end of the ramp, tie a rope to it, and thread the rope out through the top of the ark so you can use it to raise and lower the ramp as needed.


14

Building a Beehive

Backyard beekeeping makes more sense today than ever before. Not only are honey bees necessary for pollinating plants and ensuring a better fruit set and bigger crops, they produce delicious honey and valuable beeswax. And recently, the world bee population has experienced a mysterious and concerning dropoff in numbers. Getting homeowners to cultivate a bee colony is a helpful component of the preservation strategy.



Honey and beeswax are the two commodities a functioning backyard beehive will yield. If your primary interest is honey, build a traditional stacking-box style beehive in

which the bees expend most of their energy filling the premade combs with sweet honey. If it's beeswax you seek, make a top-bar hive like the one shown on the following pages.



5 Ways to Keep Your Bees safe & Healthy

1. Avoid using insecticides in your garden—Many are long-lasting and toxic to bees.

2. Buy seeds that are not treated with insecticides—Some coated seeds may cause the entire plant to become toxic to bees. Check seed packets carefully.

3. Mix your own potting soil and compost—Some composts and potting mixes sold at garden centers contain insecticide that is highly toxic to bees and other insects, and will eventually pollute all of your soil. Make your own compost, and mix with natural additives for potting plants.

4. Plant bee-friendly flowers—Buy wildflower seed mix and plant in uncultivated areas to create small sections of wild, natural habitat for your bees.

5. Provide a home for bees—Whether you're a blossoming beekeeper or not, it's easy to provide a home for bees! Provide a simple box as a place for feral bees to nest, or start your own hive.

In many ways, tending bees is like growing food. There is an initial flurry of activity in spring, followed by ongoing maintenance in the summer and then harvest in the fall. There is prep work you'll need to complete before you begin and there is a learning curve—you'll need to spend more time with your bees in the beginning until you learn how it's done. Beekeeping is not necessarily an expensive hobby, but with higher-end operations, purchasing the hive, some blue ribbon bees, and all the necessary equipment can require a significant financial investment.

Keeping bees will help you have a better garden, more fruits and vegetables, and honey in the kitchen—even beeswax candles, skin creams, and other natural cosmetics. And, by building a top-

bar beehive, you're creating a safe home and enabling one of our earth's most necessary and miraculous species to thrive.

Top-Bar Hive

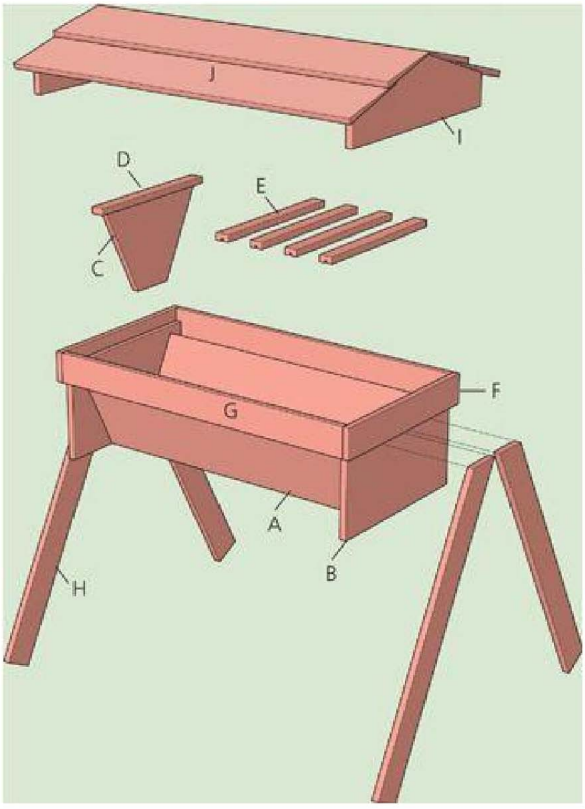
Expert beekeeper Phil Chandler insists that beekeeping should be a very simple pursuit, largely because the bees do almost all of the work for you. Chandler, who maintains a Website called The Barefoot Beekeeper (See Resources, page 158), is an advocate for natural beekeeping and has designed a top-bar hive that you can build yourself using simple materials. This hive (see pages 127 to 129) is designed to enable the bees to build their own comb, instead of relying on a premade comb.

The top-bar hive is simple in its construction and, unlike the traditional stacked box Langstroth hive, does not require that you lift heavy boxes to check on your hive's progress, which disturbs the bees within. Rather, you can simply remove the hive roof and inspect the bars one by one without disturbing the rest of the hive. Storage is minimal for a top-bar hive, as there are no supers needed. And, it is not necessary with this hive design to isolate the queen.



This simple top-bar beehive design is a warm and safe home for bees that is easily adjustable to accommodate a growing hive. This design also greatly simplifies the inspection process and minimizes the amount of equipment needed to keep and maintain bees.

Building a Top-bar Beehive



CUTTING LIST

Key	Part	No.	Dimension	Material
A	Side panel	2	¾ x 11¼ x 36"	Cedar
B	End panel	2	¾ x 11¼ x 19"	Cedar
C	Insert	2	¼ x 11½ x 15"	Cedar
D	Insert cap	2	¼ x 1½ x 17"	Cedar
E	Top Bar	20	¾ x 1½ x 17"	Cedar
F	Frame end	2	¾ x 3½ x 21"	Cedar
G	Frame side	2	¾ x 3½ x 36"	Cedar
H	Leg	4	¾ x 1½ x 36"	Cedar
I	Cap end	2	¾ x 7¼ x 23"	Cedar
J	Roofing	6	⅜ x 5⅝ x 40"	Cedar bevel lap siding

TOOLS & MATERIALS

Lumber (1 × 2, 1 × 3, 2 × 4, 1 × 12)
Carpenter's square
Pencil
Circular saw or table saw
Socket wrench
Exterior-grade construction adhesive
Caulk gun
Clamps
Drill
Tape measure
Hammer
Handsaw
1-1/4", 2", 2-1/2" deck screws
Stainless-steel mesh
Rooting nails or narrow crown staples
Eye protection
1" holesaw
3/8 × 2" galv. lag bolts with washers and nuts
Molten beeswax

How to Build a Top Bar Beehive



1 Lay out cutting lines for the insert panels on a piece of 1 × 12 cedar stock. The trapezoid-shaped panels (sometimes called followers) are meant to slide back and forth within the hive cavity, much like a file folder divider. This allows the beekeeper to subdivide the hive space as the honeycombs accumulate. The shape should be 15" wide along the top and 5" wide along the bottom (See diagram, page 127).



2 Cut the insert panels to size and shape and then attach a top cap to the top edge of each panel. The 1 × 2 caps, installed with the flat surface down, should overhang the panels by 1" at each end. Use exterior-rated wood glue and 2" deck screws driven through pilot holes to attach the tops. Also cut 20 top bars from the same 1 × 25. Use a router or table saw to cut a 1/4 × 1/4" groove in the bottom of each top bar (inset). The bees use these grooves to create purchase for their hanging honeycombs.



3 Secure the two insert panels upside down on a flat worksurface and use them to register the side panels so you can trace the panel locations onto the end panels. Center the end panels against the ends of the side panels, making sure the overhang is equal on each side. Outline the side panel locations, remove the end panels, and drill pilot holes in the outlined area.



4 Attach the end panels to the side panels with glue and 2-1/2" deck screws driven through the pilot holes in the end panels.



5 Cut the parts for the frame that fits around the top of the hive box and fasten them with glue and 1-1/4" deck screws. The top of the frame should be slightly more than 3/4" above the tops of the side panels to provide clearance for the top bars, which will rest on the side panel edges.



6 Attach the legs. First, cut 36"-long legs from 1 × 4 stock and place them over the box ends as shown in the diagram on page 127. Mark cutting lines where the leg tops intersect with the bottom of the frame. If your hive will be on grass or dirt, leave the bottom ends uncut to create a point that will help stabilize the hive. If your hive will be on a hard surface, cut the ends so they are parallel to the tops and will rest flush on the ground. Attach the legs with two or three 3/8 × 2" galvanized lag bolts fitted with washers and nuts.



7 Drill entrance holes and attach the box bottom. On one side panel, drill three 1"-dia. bee entrance holes 2" up from the bottom of the hive. One hole should be centered end to end and the others located 3" away from the center. On the other side, drill a 1"-dia. hole 2" up from the bottom of the hive and 5" from each end. Attach a steel or plastic mesh bottom with roofing nails or narrow crown staples.



8 Make and install the lid. You can design just about any type of covering you like. Here, a frame with a gable peak is made from cedar stock and then capped with beveled-lap siding (also cedar). The overlap area where the siding fits along the peak ridge should be sealed with clear exterior caulk. Add the inserts and top bars and then fit the lid frame around the box top frame.


15

Solar Electricity

When NASA scientists of the 1950s needed a revolutionary source of power for their spacecraft, they had to look and think beyond the earth. Their challenge was monumental, yet their solution poetically simple: They would find a way to tap into the most abundant, most accessible, and most reliable source of energy in the universe—the sun.



Made with lightweight materials and highly durable materials, today's low-profile solar panels are ideal for discreet rooftop installation.

Producing your own electricity with photovoltaics, or PV, is certainly one of the most exciting and rewarding ways of going green. And in addition to electrical power, homeowners everywhere are using the sun to heat water for their showers, heating systems, and even swimming pools. The economic benefits can be significant, and when you consider that supplying the average home with conventional power creates over three tons of carbon emissions each year (over twice that of the average car), the environmental benefits of pollution-free solar energy are nothing to squint at.

This chapter introduces you to the most popular solar options for supplementing your existing systems or even declaring energy independence by taking your home "off the grid." As solar technology continues its journey from the space program to suburban rooftops and beyond, anyone serious about climbing aboard will find a vibrant new marketplace that's more than ready to help.



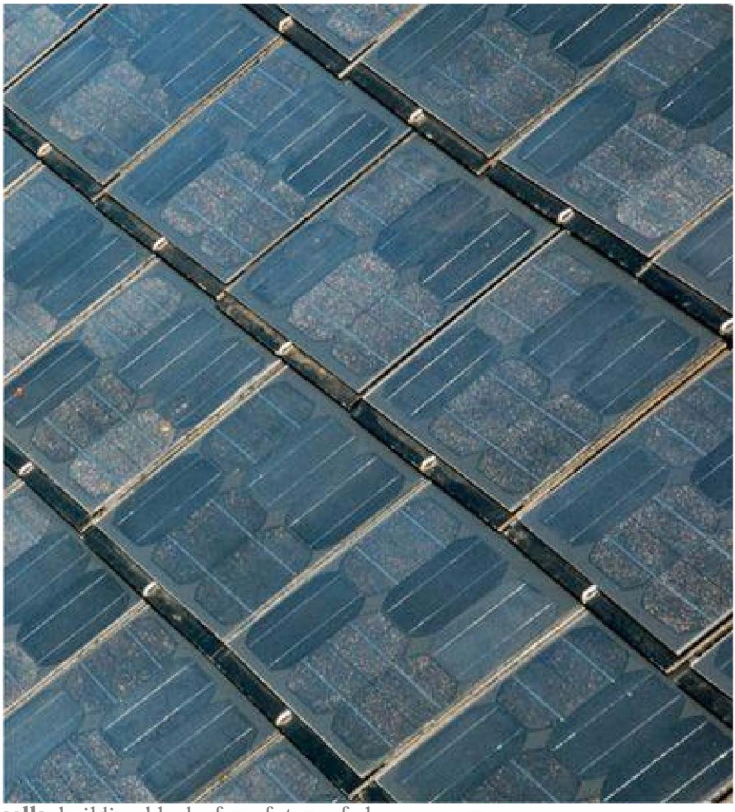
New solar products have made it easier to be green in urban locations. Here, slim solar panels are secured to a homeowner's balcony in the city.



Being off the grid means no electric bill, no concerns about rate hikes, and no utility-based power outages.

Solar Electricity

Residential PV systems supply electricity directly to a home through solar panels mounted on the roof or elsewhere. These are essentially the same systems that pioneering homeowners installed back in the 1970s, except in those days panels were less efficient and much more expensive—to the tune of over $300 per watt in setup costs compared to around $9 per watt today (and people in many areas can cut that number in half with renewable energy rebates and tax credits).



Solar cells: building blocks for a future of clean energy.

Here's how PV power works: A solar panel is made up of small solar cells, each containing a thin slice of silicon, the same stuff used widely in the computer industry. Silicon is an abundant natural resource extracted from the earth's crust. It has semi-conductive properties, so that when light strikes the positive side of the slice, electrons try to move to the negative side. By connecting the two sides with a wire, you create an electrical circuit and a means for harnessing this electrical activity.

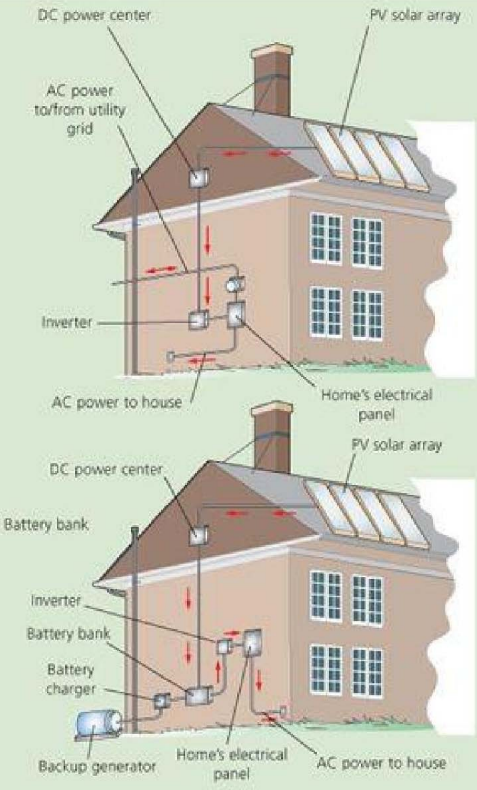
Solar cells are grouped together and connected by wires to create a module, or panel. Modules can be installed in a series to create a solar "array." The size of an array, as well as the quality of the semiconductor material, determines its power output.

The electricity produced by solar cells is DC, or direct current, which is what most batteries produce and what battery-powered devices run on. Most household appliances and light fixtures run on AC, or alternating current, electricity. Therefore, PV systems include an inverter that converts the DC power from the panels to AC power for use in the home. It's all the same to your appliances, and they run just as well on solar-generated power as on standard utility power.

Grid-Connected & Off-the-Grid Systems

Home PV systems can be designed to connect to the local utility network (the power grid) or to supply the home with all of its electricity without grid support. There are advantages and disadvantages to each configuration.

In a grid-connected setup, the utility system serves as a backup to supply power when household demand exceeds the solar system's capacity or during the hours when the sun is down. This obviates the need for batteries or a generator for backup and makes grid-connected systems simpler and less expensive than off-the-grid systems. One of the best advantages of grid connection is that when the solar system's output exceeds the house's demand, it delivers power back to the grid and you (may) get credit for every watt produced. This is called net-metering and is guaranteed by law in many states; however, not every state requires utility companies to offer it, and not all companies offer the same payback. Some simply let the meter roll backwards, essentially giving you full retail value for the power, while others buy back power at the utility's standard production price—much less than what they charge consumers.



Grid-connected systems (top) rely on the utility company for supplemental and backup energy. Off-the-grid systems (bottom) are self-sufficient and must use batteries for energy storage and a generator (usually gas-powered) for backup supply.

The main drawbacks of being tied to the grid are that you may still have to pay service charges for the utility connection even if your net consumption is zero, and you're still vulnerable to power outages at times when you're drawing from the grid. But the convenience of grid backup combined with the lower cost and reduced maintenance of grid-tied systems makes them the most popular choice among homeowners in developed areas.

Off-the-grid, or standalone, systems serve as the sole supply of electricity for a home. They include a large enough panel array to meet the average daily demand of the household. During the day, excess power is stored in a bank of batteries for use when the sun is down or when extended cloud cover results in low output. Most standalone systems also have a gas-powered generator as a separate, emergency backup.

For anyone building a new home in an undeveloped area, installing a complete solar system to provide your own power can be less expensive than having the utility company run a line out to the house (beyond a quarter-mile or so, new lines can be very costly). There are some maintenance costs, namely in battery replacement, but it's possible to save a lot of money in the long run, and never having to pay a single electric bill is deeply satisfying to off-the-grid homeowners.

As mentioned, off-the-grid systems are a little more complicated than grid-tied setups. There are the batteries to care for, and power levels have to be monitored to prevent excessive battery run-down and to know when generator backup is required. To minimize power demands, off-the-grid homes tend to be highly energy-efficient. Using super-efficient appliances and taking smaller steps like connecting electronics to power strips that can be switched off to prevent small but cumulative energy losses from devices running in "standby" mode enables homeowners to get by with smaller, less expensive solar arrays. If you're interested in taking your home off the grid, talk with as many experts and off-the-grid homeowners as you can. Their experiences can teach you invaluable lessons for successful energy independence.

Solar Panel Products

PV modules come in a range of types for different applications and power needs. The workhorse of the group is the glass- or plastic-covered rigid panel that can be mounted to the roof of a house or other structure, on an exterior wall, or on the ground at various distances from the house. Panel arrays can also be mounted onto solar-powered tracking systems that follow the sun for increased productivity.



Mounting solar arrays on the ground offers greater flexibility in placement when rooftop installation is impractical or prohibited by local building codes or homeowners associations.

Rigid modules, sometimes called framed modules, are designed to withstand all types of weather, including hail, snow, and extreme winds, and manufacturers typically offer warranties of 20 to 25 years. Common module sizes range in width from about 2 ft. to 4 ft. and in length from 2 ft. to 6 ft. Smaller modules may weigh less than 10 pounds, while large panels may be 30 to 50 pounds each.

In addition to variations in size, shape, wattage rating, and other specifications, standard PV modules can be made with two different types of silicon cells. Single crystalline cells contain a higher grade of silicon and offer the best efficiency of sunlight-to-electricity conversion—typically around 10% to 14%. Multicrystalline, or polycrystalline, cells are made with a less exacting and thus cheaper manufacturing process. Solar conversion of these is slightly less than single crystalline, at around 10% to 12%, but warranties on panels may be comparable. All solar cells degrade slowly over time. Standard single crystalline and multicrystalline cells typically lose 0.25% to 0.5% of their conversion efficiency each year.

Amorphous Solar Cells

Another group of solar products are made with amorphous, or thin-film, technology in which noncrystalline silicon is deposited onto substrates, such as glass or stainless steel. Some substrates are flexible, allowing for a range of versatile products, including self-adhesive strips that can be rolled out and adhered to metal roofing and thin solar modules that install just like traditional roof shingles. Amorphous modules typically offer lower efficiency—around 5% to 7%—and a somewhat faster degradation of 1% or more per year.



Installing solar panels over an arbor, pergola, or other overhead structure can create a unique architectural element. Here, panels over an arbor provide shade for a patio space while generating electricity for the house.

The Economics of Going Solar

While the environmental benefits of solar electricity are obvious and irrefutable, most people looking into adding a new solar system need to examine the personal financial implications of doing so. PV systems cost only a small fraction of what they did 30 years ago, but they're still quite expensive. For example, a three-kilowatt system capable of supplying most or all of the electricity for a typical green home can easily cost $30,000 (before rebates and credits) and take 20 to 25 years to pay for itself in reduced energy bills. An off-the-grid system will cost even more. Nevertheless, depending on the many factors at play, going solar can be a sound investment with a potentially high rate of return.

One way to consider solar as an investment is to think of it as paying for a couple of decades' worth of electricity bills in advance. Thanks to the long warranties offered by manufacturers and the reliability of today's systems, the costs of maintenance on a system are predictably low. This means that most of your total expense goes toward the initial setup of the system. If you divide the setup cost (after rebates and credits) by the number of kilowatt hours (kWh) the system will produce over its estimated lifetime, you'll come up with a per-kWh price that you can compare against your current utility rate. Keep in mind that your solar rate, as it were, is locked in, while utility rates are almost certain to rise over the lifetime of your system.

Now, about those rebates and credits: In many areas, homeowners going solar can receive sizable rebates through state, local, or utility-sponsored programs, in addition to federal tax credits, as applicable. All told, these financial incentives can add up to 50% or more of the total setup cost of a new PV system. To find out about what incentives are available through any of these sources, check out the Database of State Incentives for Renewables & Efficiency, online at www.dsireusa.org. Established solar businesses in any given area are also very well informed about incentives available to local residents.

Here are some of the factors that tend to affect the cost of a PV system, its effectiveness or efficiency, and the homeowner's return on investment:

- The house and geographic location—how much sun reaches the house; the roof's slope and roofing material
- Electric utility rates and net-metering rates
- Increased home value—PV systems and other energy-saving upgrades can increase a home's resale value (often without raising the property value used for tax assessment)
- Loan rate, if the system is financed



This fiber-cement shingle roof features an integrated array of shingles laminated with thin-film PV modules.

With so many factors to consider, getting to the bottom line can be complicated. Full-service solar companies will perform a cost/benefit analysis to help potential customers make a decision based on the financial picture. Of course, you should always check their numbers and scrutinize any variables used. You can also learn a lot by talking to other homeowners in your area who have had similar systems installed. Are they getting the return they expected? Have their systems been reliable and low-maintenance? Would they change anything given the chance to do it over?

Working with Solar Professionals

Companies that provide solar equipment and system design, installation, and maintenance services are rising in number every year. A few of these were around during the lean years of the 1980s and '90s, but many more have sprouted up in the last decade or so. In any case, this is now a highly competitive industry, so you can, and should, expect great service at competitive prices.

The reputation and reliability of your local solar provider are important considerations, but perhaps more important is the stability of the original equipment manufacturers (OEMs) who produce the main parts of your system and who carry those long warranties. Many of these are large, well-established companies with expertise in energy and/or electronics, so it's a good bet they'll be around in 20 or 25 years to honor their product warranties. Always discuss warranties carefully with your solar provider.

At present, the solar industry really isn't set up for do-it-yourself system design and installation. Professional installation may run you around 15% of the total system cost—quite a low rate for the home improvement industry—and that amount is subject to rebates and credits, which are based on installed system prices.

Before giving you a quote for the system package, a solar provider will want to know about your home, what type of roofing you have, and what the southern exposure is like. To ballpark the size of system you'll need, they'll probably look at your utility bills from the past year and ask how much power you want to get from solar: Will it cover all household demand or just a portion of it? You may have to pay a fee to cover the provider's legwork required for working up an accurate quote.

Services likely to be included in a provider's system package are:

- Complete system design and installation
- Guarantees on workmanship/installation
- Obtaining building/electrical permits

- Coordinating hookup with utility company
- Obtaining rebates and credits
- Help with OEM warranty claims
- Lifetime technical support

Another thing to be aware of when comparing various providers' quotes, and in talking to other customers, is the actual output of a panel or array as opposed to its STC (or "name plate") wattage rating. Industry sources say the actual useable power of a system is typically about 75% of the rated power. This means that if your home needs three kilowatts of power your system should be rated for four kilowatts.

Solar for Hot Water & Heating

The science behind solar water heating is quite simple: If you've ever turned on a garden hose that's been left out in the sun (only to get extremely hot water when you expected cold), you pretty much get how it works. In a basic solar hot water system, water or an antifreeze fluid is circulated through rooftop collector units, then down into the house (or swimming pool) where it feeds a system to supply domestic hot water or to supplement space heating equipment.

Solar hot water systems are used in many different climates and are inexpensive and reliable enough to yield relatively quick financial returns in addition to long-term environmental benefits. For most homes, the solar system is used in conjunction with conventional heating equipment, such as a hot water heater or boiler, providing preheated water to the system to reduce its net energy use. On average, solar heaters for domestic hot water are most cost-effective when they supply around 70% of a home's hot water. Solar systems supplementing heating equipment are most cost-effective when designed to offset 40% to 80% of the home's annual demand.

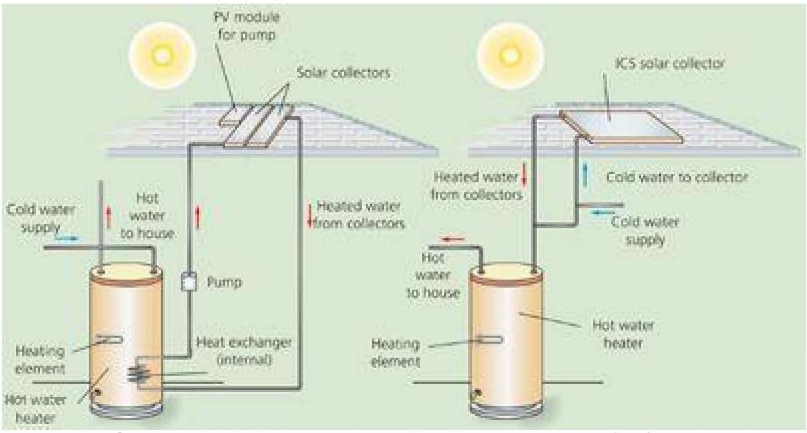
Types of Hot Water Systems

The basic setup of a solar hot water system includes one or more collectors, a storage tank, various control devices, and a network of piping. Indirect systems circulate the same water or fluid through a continuous pipe loop and transfer heat via a heat exchanger. Direct systems run fresh water through the collector's piping and into the home for direct use.

Systems are also defined by their means of circulation. Active heaters use a pump to move the water or fluid mechanically; passive heaters move water without pumps, usually through the natural process of thermosyphoning: As the water in the collector heats up, it flows into a storage tank while cold water refills the collector tubes.

Solar heaters for domestic hot water may include a separate storage tank that feeds preheated water into a standard tank-style

hot water heater or a tankless on-demand heater. The water heater can then boost the temperature of the water as needed. In other systems, solar-heated water is fed directly into a hot water tank, which typically contains its own conventional heat source.

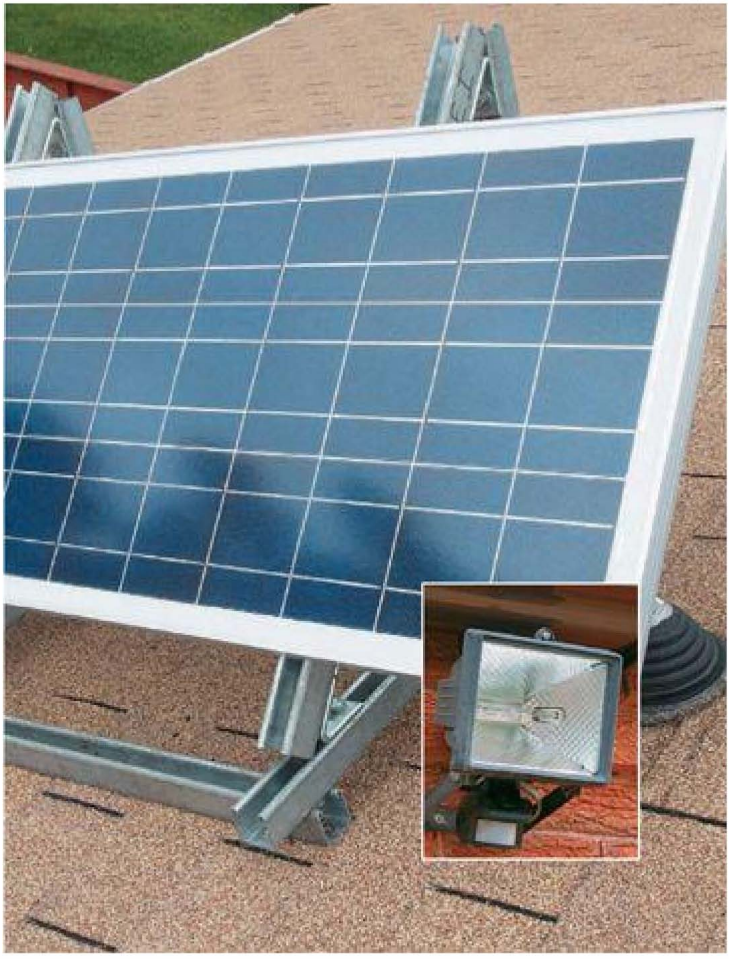


Two systems for domestic hot water: An indirect, active system (left) heats water via a heat exchanger inside a hot water tank and uses a pump to circulate fluid to and from the solar collectors. A direct, passive system (right) heats the same water that gets used in the house and relies on natural processes for circulation.

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Solar Security Light Circuit

A self-contained electrical circuit with dedicated loads, usually 12-volt light fixtures, is one of the most useful solar amenities you can install. A standalone system is not tied into your power grid, which greatly reduces the danger of installing the components yourself. Plus, the fact that your light fixtures are independent of the main power source means that even during a power outage you will have functioning emergency and security lights.

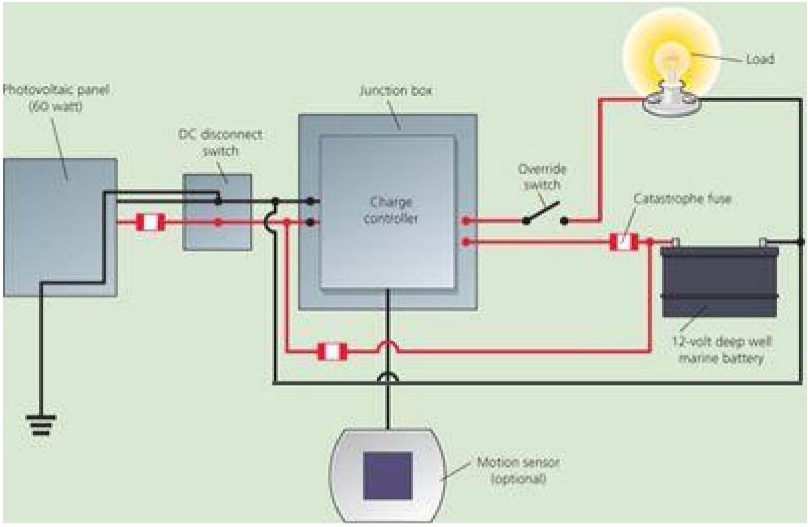


This 60-watt solar panel is mounted on a garage roof and powers a self-contained home security lighting system. Not only does this save energy costs, it keeps the security lights working even during power outages.

Installing a single solar-powered circuit is relatively simple, but don't take the dangers for granted. Your work will require permits and inspections in most jurisdictions, and you can't expect to pass if the work is not done to the exact specifications required.

Solar panels that convert the sun's energy into electricity are called photovoltaic (PV) panels, and they produce direct current (DC) power. PV solar panel systems can be small and designed to accomplish a specific task, or they can be large enough to provide power or supplementary power to an entire family's home. Before you make the leap into a large system, it's a good idea to familiarize yourself with the mechanics of solar power. The small system demonstrated in this project is relatively simple and is a great first step into the world of solar. The fact that the collector, battery, and lights are a standalone system makes this a very easy project to accomplish. By contrast, **installing panels that provide direct supplementary power through your main electrical service panel is a difficult wiring job that should be done by professional electricians only.**

DC Light Circuit Schematic



TOOLS & MATERIALS

Tape measure
Drill/driver with bits
Caulk gun
Crimping tool
Wiring tools
Metal-cutting saw
Photovoltaic panel (50 to 80 watts)
Charge controller
Catastrophe fuse
Battery sized for 3-day autonomy
Battery case
Battery cables
12-volt LED lights including motionsensor light
Socket wrench
20 ft. Unistrut 1-7/8" thick U-channel (See Resources, page 158)
(4) 45° Unistrut connectors
(2) 90° Unistrut angle brackets
(4) Unistrut hold-down clamps
(12) 3/8" spring nuts
(12) 3/8 × 1" hex-head bolts with washers
DC-rated disconnect or double-throw snap switch
6 ft. length of 1/2" liquid-tight flexible metallic conduit
(2) 1/2" liquid-tight connectors
(2) Lay-in grounding lugs
(2) Insulated terminal bars to accept one 2-gauge wire and four 12-gauge wires
(2) Cord cap connectors for 1/2" cable
1/2" ground rod and clamp
Copper wire (6-, 12-gauge)
Green ground screws
1/2" flexible metallic conduit or Greenfield
1/2" Greenfield connectors
(4) 11/16" junction boxes with covers
(4) square boxes with covers
6 × 6" junction box with cover
14/2 UF wire

1/4 × 20 nuts and bolts with lock washers
Roof flashing boot
Roof cement
Silicon caulk

Installing an Off-the-Grid Solar Lighting System

Before you begin installing a standalone solar-powered circuit, you'll need to make some basic determinations. The panel location is chief among these questions. Position the solar panel where it will receive the greatest amount of sunlight for the longest period of time each day—typically the south-facing side of a roof or wall. For a circuit with a battery reserve that powers two to four 12-volt lights, a collection panel rated between 40 and 80 watts of output should suffice. These panels can range from $200 to $600 in price, depending on the output and the overall quality.

Mounting the Panel

The photovoltaic panel must be securely mounted on a permanent stand and then connected via wires to the power distribution hardware inside the structure. Although some low-wattage panels come with a mounting stand, on larger PV panels you'll need to construct the mounting structure yourself using metal U-channels or other materials. The stand seen in this project is constructed with channels and fittings to secure the panel in a south-facing position on a garage roof. The structure is made with Unistrut brand metal channel and hardware (see Resources, page 158).



The mounting stand for the PV panel is constructed from metal U-channel and pre-bent fasteners. Electrical connections to the power distribution system are made inside the garage.



The stand components are held together with bolts and spring-loaded fasteners. The 45° and 90° connectors are manufactured specifically for use with this Unistrut system.



Connections for the feed wires that carry current from the collector are made inside an electrical box mounted on the back of the collector panel.

First, install two tracks of U-channel on the roof, parallel to the long edges of the panel. Attach the channels to the roof deck use the mounting hardware designed for your mounting system. Mount two 30° beam clamps onto the U-channel tracks to hold the panel at the best angle for maximum sunlight exposure.

Determine the location of the wire leads that penetrate the roof and will connect to the charge controller and battery. Mark the position for the leads onto the roof and use a 7/8" drill bit to bore an opening in the roof at this mark. Install a roof flange with a rubber boot over the opening and insert a section of 3/4"-dia. PVC conduit into the boot. Seal all casing connections with silicon caulk.

Attach the panel to the stand beam clamps and thread the lead wires through the PVC conduit leading into the structure. Tighten all bolts securely. Check that the panel fits tightly into the clamps and does not move even slightly when agitated.

Make Interior Wiring Connections

Mount a junction box inside the building directly underneath the PVC conduit and wiring entry point, attaching it to a rafter or truss. Secure the box to the PVC conduit and seal with silicon caulk. Feed the lead wires from the PV panel into the junction box.

On a wall at roughly switch height, install a DC disconnect switch in a junction box. The disconnect switch allows you to shut off the flow of electrical current from the solar panel. Attach a junction box to enclose the DC disconnect to a wall stud near the battery and charge controller location. Run flexible metal conduit along the rafters or trusses and wall studs from the ceiling junction box to the DC disconnect box.



An EPDM rubber boot seals off the opening where the PVC conduit carrying the feed wires penetrates the roof.



The feed wires from the collector are fed into a junction box inside the structure where connections to the power distribution equipment are made.

Attach a junction box beneath the DC disconnect box to enclose the charge controller. Connect the controller to the DC disconnect box with flexible metal conduit. Install the charge controller inside the box. About 2" away from the charge controller, mount a touch-safe fuse holder with a 10-amp "catastrophe" fuse as well.

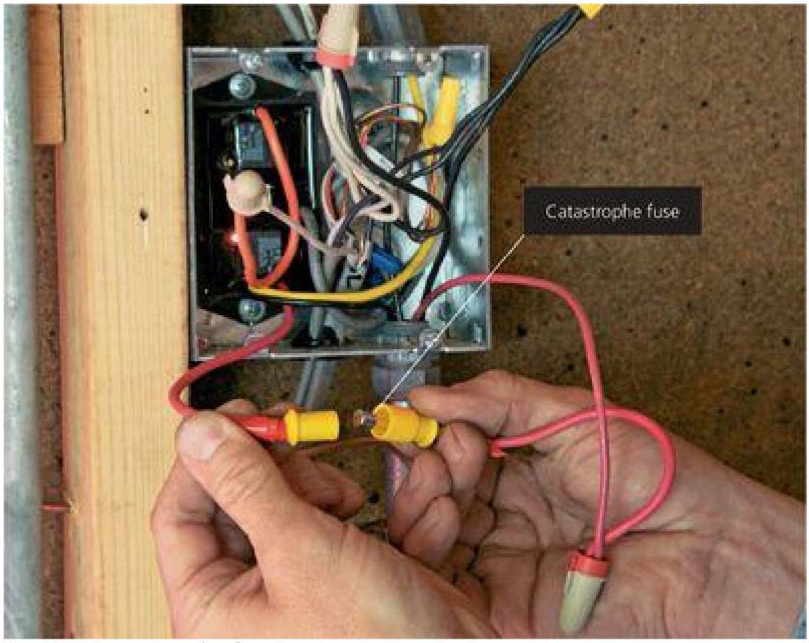
Determine the placement of the battery and then decide where you will position the charge controller and DC disconnect nearby. The battery should be placed at least 18"off the floor in a well-ventilated area, where it won't be agitated by everyday activity.

Build the battery shelving. Securely attach the plastic battery casing to a plywood shelf with wood screws.

Set up grounding protection by pounding an 8-ft. long ground rod into the earth outside the building, about 1 foot from the wall on the opposite side of the charge controller. Leave about 2" of the rod sticking out of the ground. Attach a ground rod clamp to the top of the rod. Run a 6-gauge THWN wire from the ground rod to the bottom of the DC disconnect box. Cut the wire, leaving about 8" of length inside the DC disconnect box.

Run wiring from the disconnect switch to the ceiling junction box. Thread 6-gauge wire through the PVC conduit and attach it directly to a metal component of the PV panel. This wire will run down to the grounding rod for lightning protection.

Attach the two 14-gauge wires to the two terminals labeled "line" on the top of the DC disconnect switch. Route two more 14-gauge wires from the bottom of the DC disconnect terminals into the junction box and connect to the "Solar Panel In" terminals on the charge controller. The black wire should connect to the negative terminal and the red to the positive. Screw a ground pigtail into the DC disconnect box and splice together both 6-gauge wires and the ground tail into a red wire connector.

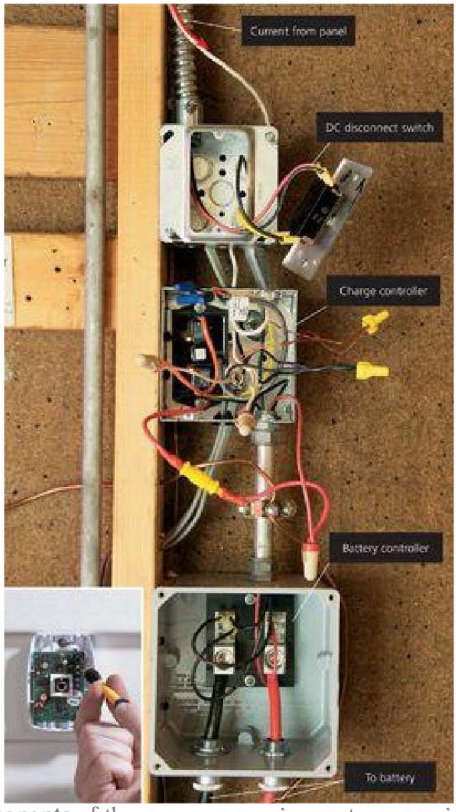


A 10-amp "catastrophe fuse" is inserted in the incoming current line to protect the fixtures from damaging power surges, most often the result of a lightning strike.

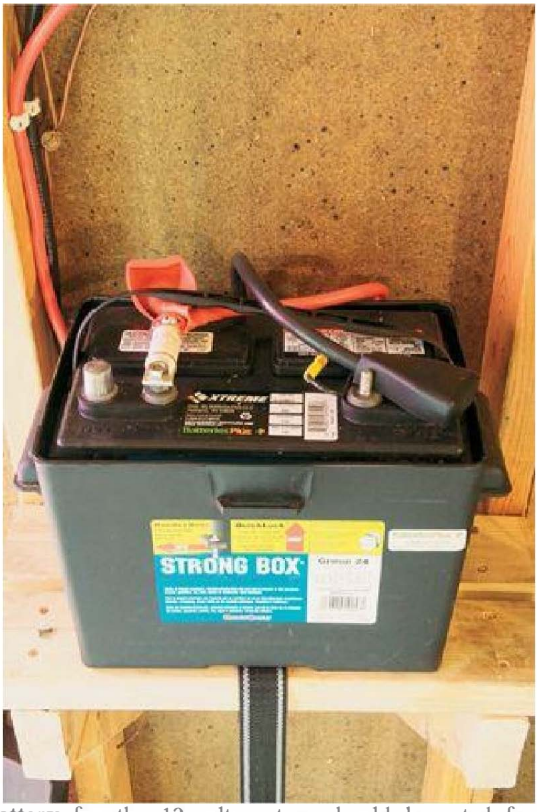
Connect the charge controller to the battery. Run a 14-gauge wire from the charge controller output that goes to the battery to the line side of the touch-safe fuse. From the load side of the touch-safe fuse holder, run 14-gauge wire through the heavy-duty cable leading to the positive battery terminal location. Crimp the end to the eyelets of the battery casing. Crimp the negative battery terminal wire to the battery casing and route the wire through the second cable into another hole in the bottom of the charge controller junction box and connect to the charge controller at the designated location.

Install the lighting fixtures and hook them up to the power source with UF cable.

Make sure the disconnect switch is in the off position. Attach the crimped ends of the lead wires to the battery terminals and put the cover on the battery. At this point, label all wires and seek approval from your local building inspector. Connect the panel to the circuit. To stop the power flowing from the panel, cover it temporarily but securely with an opaque bag or blanket. Attach the black wire from the PV module to the negative lead and the red wire from the panel to the positive lead with yellow wire nuts. Fold the wires into the box and secure the cover onto the box. Remove the bag from the panel and turn the DC disconnect switch on to complete the circuit.



The electrical components of the power processing system are wired in series through electrical boxes mounted inside the structure. The principal components include the disconnect switch (top box), a charge controller (middle box), and a battery controller (bottom box). An optional motion sensor (inset) triggers the lights.



The storage battery for the 12-volt system should be rated for three days of autonomous usage. Mount the battery in a sturdy plastic case that's at least 18 in. above ground.


17

Solar Heat

Most homes, and especially older ones, are beset by one stubborn room that just never quite warms up—whether it's a remote second floor bedroom, a kitchen or dining room with large, north-facing windows, or a main floor office in the corner closed off from the home's central heating system. Operating an electric space heater can help you warm up in the short-term, but is not an energy-efficient or long-term solution to this problem. One very efficient long-term solution, however, is to build and install hot-air solar panels. Even if you don't have a cold spot, a supplementary solar heat system can save plenty of energy dollars.

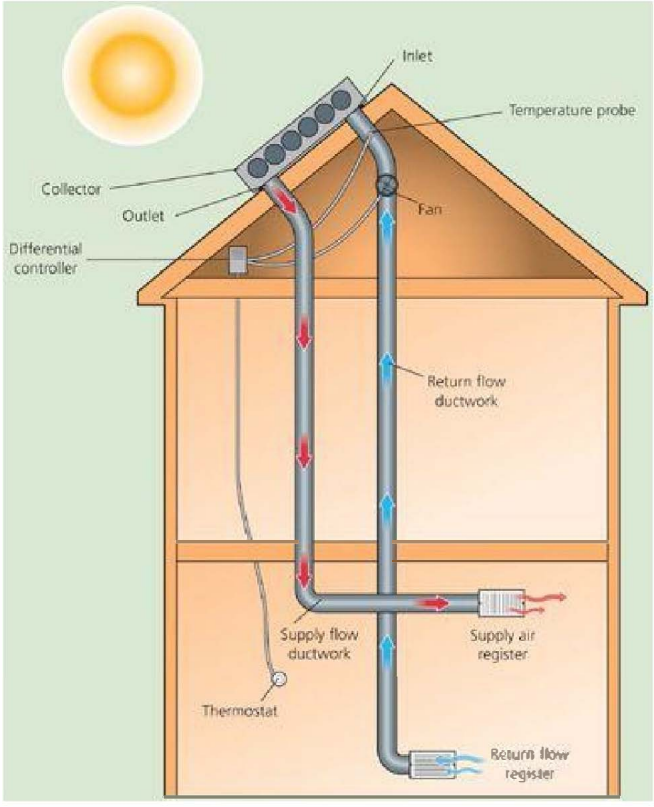


When combined, these three DIY “hotboxes” introduce enough hot air into this home to carry 30 to 40% of the home heating load.

Using solar energy to heat a cold space in your home is a great way to harvest the sun's energy and supplement your home's heat in these problem areas. Solar hot air panels are fundamentally different than photovoltaic panels—this style is designed to use the sun's energy to heat the air inside each box rather than to create electricity. Mounted on a south-facing wall or on the roof, solar hot air panels collect air from inside your home and blow or draw it through the thermal solar panels, which are essentially a series of metal ducts in a black box under tempered glass. As the air moves through the ductwork, the sun's rays cause it to heat to high temperatures. Then, at the end of the duct, another vent moves the air back into your home's heating ductwork or an interior vent, sending the now-heated air right into the home.

You can build solar hot air panels yourself. This style seen here is simple: essentially, a box, a series of ducts, and a piece of glass. The panels are permanently installed and ducted in to your home, complete with automated thermostatic controls. In this project, we'll walk you through one version of a solar hot air panel designed and installed by Applied Energy Innovations of Minneapolis, Minnesota (see Resources p. 158), with the help of homeowner Scott Travis.

Anatomy of a Hot Air Solar Panel



The solar hot box is a very simple system. Cold air from the house is drawn up into a network of ducts in the collector, where it is warmed by the sun then circulated inside to heat the house.



The temperature control equipment opens and closes the damper and causes the blower fan to turn on and off as needed.

TOOLS & MATERIALS

Jigsaw or circular saw with metal-cutting blade
Drywall saw
Straightedge
Aviation snips
Tape measure
Eye and ear protection
Carpenter's square
Drill/driver with bits
1/8" pop rivets
Pop rivet gun
High-temperature silicon caulk
Caulk gun
Aluminum foil tape
1"-thick R7 rigid insulation
2 × 6 steel studs
Utility knife
Tempered glass
4" hole saw
Sheet-metal start collars
8" plenum box (2)
4" male and female duct connectors
1"-wide closed-cell foam gasket
4" aluminum HVAC duct
High-temperature black paint (matte)
Trim paint roller
Sheet-metal screws with rubber gaskets
Chalkline
Cardboard
Scissors
Reciprocating saw
Roof jack
Roofing cement
Flashing
Rubber gasket rooting nails
Shingles (if needed)
Unistrut

Unistrut connectors
Duct collars (2)
3/8" threaded rod
Spring-fed 8" backdraft dampers
8" blower fan
Temperature controls

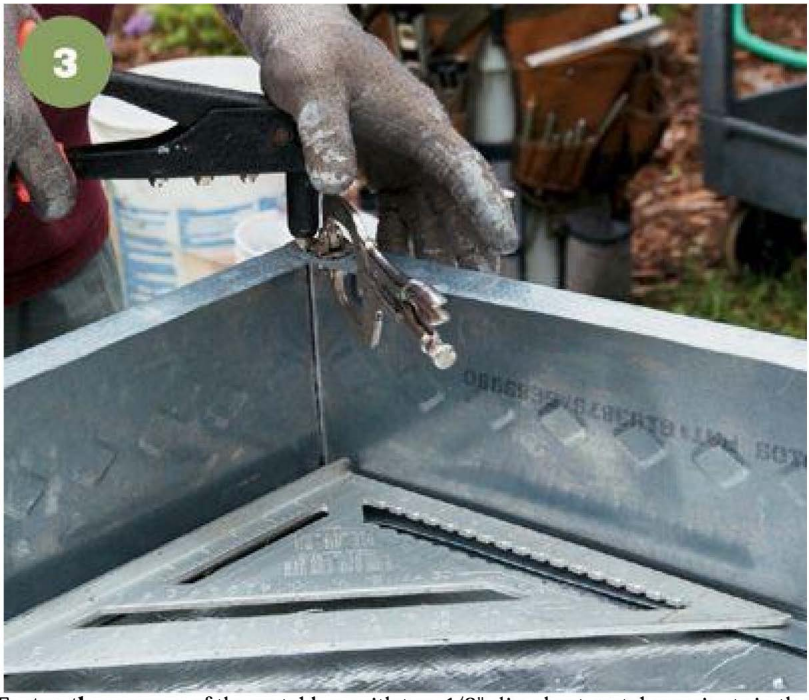
How to Build a Solar Hot Air Panel



1 Cut and bend the box frame pieces from 2 × 6 steel studs. Each steel stud piece will wrap two sides of the panel with a 90° corner bend. Mark the bend location on both steel studs. Cut a relief cut into the 6" side of the stud with aviation snips at this mark. Bend the stud to an L-shape and use a square to ensure that the corner forms a true 90° angle.



2 Drill 1/8"-dia. holes in the overlapping top and bottom flanges. Clamp the corners together before drilling and use a square to make sure the corner forms a 90° angle.



3 Fasten the corners of the metal box with two 1/8"-dia. sheet-metal pop rivets in the top and bottom. Leave one corner open to create access for the insulation panel insert.



4 Cut the foil-faced rigid foam insulation to match the interior dimensions of the box, using a drywall saw or a utility knife.



5 Apply high-temperature silicon to the bottom flanges of the box (inset). Fit the 1" foil-face rigid foam insulation into the back of the frame, then close up the box and secure the open corner. Cut 5"-wide strips of foam insulation to the length and width of the panel. Place a thick bead of silicon around the outside perimeter of the unit. Insert the strips into the silicon and tightly against the sides of the panel to hold the backing firmly in place. The foil should be facing into the box.



6 Seal the insulation edges. Place a bead of silicon around the inside corner where the insulation strips and backing panel meet, and then seal with foil tape. Flip the panel over. Place a bead of silicon on the intersection of the 2 × 6 stud flange and the back of the insulation and seal with foil tape. Conceal any exposed insulation edges with foil tape.



7 Create inlet and outlet holes in the walls with a hole saw or circle cutter. The number and location of the ductwork holes depends on where each panel fits into the overall array (presuming you are making and installing multiple panels). The first and last panels in the series each will have one end wall that is uncut, while intermediate panels will have duct holes on each end wall (inset).



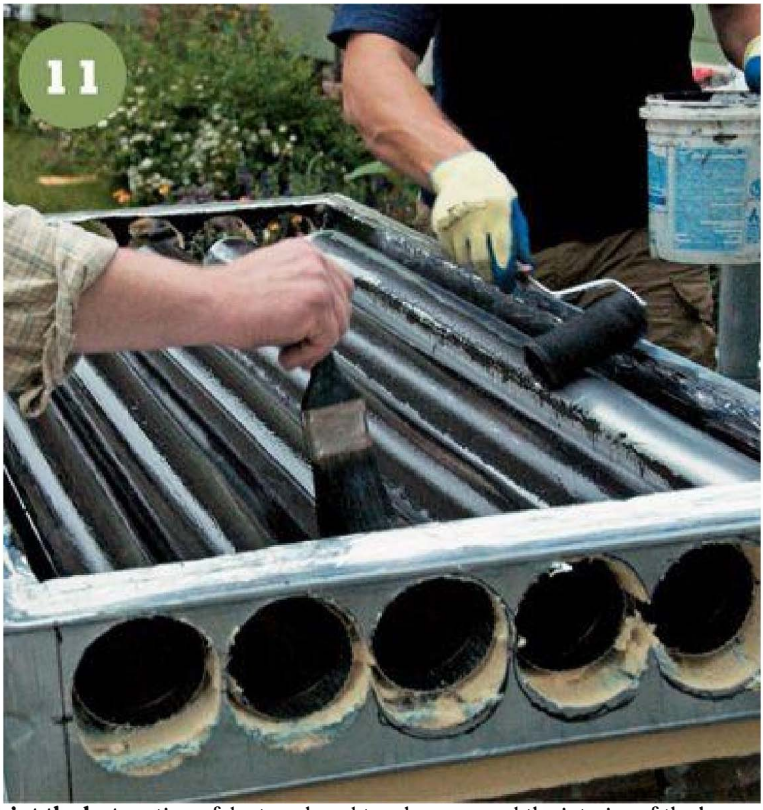
8 Install a compartment separator in the first and last panels with a piece of foil insulation set on edge. Cut ductwork access holes in the separator. Then, cut out holes for the ductwork that will pass through the separator. Also cut a plenum opening in the separated compartment in the first and last unit.



9 Paint the entire box interior black using high-temperature paint and allow it to dry completely. A trim roller works well for this task.



10 Insert the ductwork. Beginning at the plenum over the inlet duct, guide 4" aluminum HVAC ductwork in a serpentine shape throughout the entire multi-panel installation, ending at the outlet duct. Join ends of adjoining duct sections with flexible duct connectors fashioned into a U shape and secured with metal screws and foil tape (inset). Paint each section of ductwork with black high-temperature paint once it is in place.



11 Paint the last section of ductwork and touch up around the interior of the box so all exposed surfaces are black.



12 Affix the glass top. First, double check that all openings in the panel are adequately sealed and insulated. Then, line the tops of the steel stud frame with foam closed-cell gasket tape. Carefully position the glass on top of the gasket tape, lined up 1/2" from the outside of the frame on all sides. Then, position foam closed-cell gasket tape around the perimeter of the top of the glass panel.



13 Attach the casing. Work with a local metal shop to bend metal flashing that will wrap your panel box. Attach around the perimeter of the panel with sheet-metal screws with rubber washer heads. **TIP:** Be careful when working around the plenum ductwork. If you set the unit down on its backside, you will force the plenum up and break the seal around the opening.



14 Mark off the panel layout locations on the roof. Transfer the locations of the 8"-dia. inlet and outlet holes to the roof as well. The location of these holes should not interfere with the structural framing members of your roof (either rafters or trusses). Adjust the panel layout slightly to accommodate the best locations of the inlet and outlet, according to your roof's setup. Cut out the inlet and outlet holes with a reciprocating saw.



15 Use a roof jack or Cone-jack to form an 8"-dia. opening. Apply a heavy double bead of roofing cement along the top and sides of the roof jack. Nail the perimeter of the flange using rubber gasket nails. Cut and install shingles with roofing cement to fit over the flashing so they lie flat against the flange.



16 Attach Unistrut mounting U-channel bars to the roof for each panel. Use the chalklines on the roof to determine the position of the Unistrut, and attach to the roof trusses with Unistrut connectors.



17 Hoist the panels into position. Carefully follow safety regulations and use scaffolding, ladders, ropes, and lots of helpers to hoist the panels onto the roof. Wear fall-arresting gear and take care not to allow the plenum ductwork to be damaged. Connect the inlet and outlet ducts on the panel(s) to the openings on the roof (inset). Position the panels so the inlet and outlet openings match perfectly, and attach with a duct collar and silicon caulk.



18 Connect the panels to the Unistrut with 3/8" threaded rod attached at the top and bottom of the panel on the outside. Cut threaded rod to size, then attach to the Unistrut with Unistrut nuts. Attach the top clip to the top of the rod and the front face of the panel. Tighten the assembly to compress the panel down to the Unistrut for a tight hold. Seal the panel connections with 1" foam gasket tape around each end of the panels where they connect. Place a bead of silicon caulk on top of the gasket tape and then attach 3"-wide flashing over the two panels at the joint. Attach flashing to the panel with galvanized sheet metal screws with rubber gasket heads.



19 Hook up the interior ductwork, including dampers and a blower fan. The manner in which this is done will vary tremendously depending on your house structure and how you plan to integrate the supplementary heat. You will definitely want to work with a professional HVAC contractor (preferably one with experience with solar) for this part of the job.

Conversions

Metric Equivalent

Inches (in.)	1/64	1/32	1/25	1/16	1/8	1/4	3/8	5/8	1/2	5/8	3/4	7/8	1	2	3	4	5	6	7	8	9	10	11	12	36	39.4
Feet (ft.)																								1	3	3 1/32
Yards (yd.)																									1	1 1/32
Millimeters (mm)	0.40	0.79	1	1.59	3.18	6.35	9.53	10	12.7	15.9	19.1	22.2	25.4	50.8	76.2	101.6	127	152	178	203	229	254	279	305	914	1,000
Centimeters (cm)							0.95	1	1.27	1.59	1.91	2.22	2.54	5.08	7.62	10.16	12.7	15.2	17.8	20.3	22.9	25.4	27.9	30.5	91.4	100
Meters (m)																								.30	.91	1.00

Converting Measurements

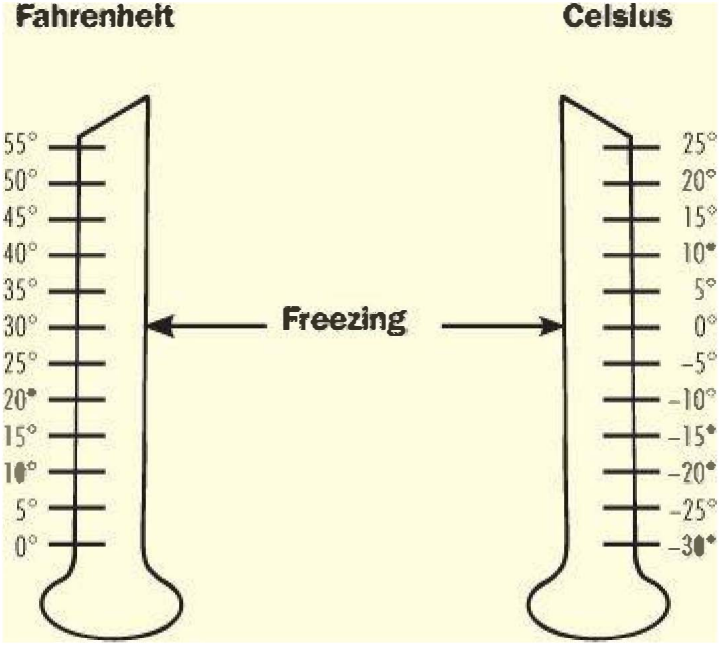
To Convert:	To:	Multiply by:
Inches	Millimeters	25.4
Inches	Centimeters	2.54
Feet	Meters	0.305
Yards	Meters	0.914
Miles	Kilometers	1.609
Square inches	Square centimeters	6.45
Square feet	Square meters	0.093
Square yards	Square meters	0.836
Cubic inches	Cubic centimeters	16.4
Cubic feet	Cubic meters	0.0283
Cubic yards	Cubic meters	0.765
Pints (U.S.)	Liters	0.473 (Imp. 0.568)
Quarts (U.S.)	Liters	0.946 (Imp. 1.136)
Gallons (U.S.)	Liters	3.785 (Imp. 4.546)
Ounces	Grams	28.4
Pounds	Kilograms	0.454
Tons	Metric tons	0.907

To Convert:	To:	Multiply by:
Millimeters	Inches	0.039
Centimeters	Inches	0.394
Meters	Feet	3.28
Meters	Yards	1.09
Kilometers	Miles	0.621
Square centimeters	Square inches	0.155
Square meters	Square feet	10.8
Square meters	Square yards	1.2
Cubic centimeters	Cubic inches	0.061
Cubic meters	Cubic feet	35.3
Cubic meters	Cubic yards	1.31
Liters	Pints (U.S.)	2.114 (Imp. 1.76)
Liters	Quarts (U.S.)	1.057 (Imp. 0.88)
Liters	Gallons (U.S.)	0.264 (Imp. 0.22)
Grams	Ounces	0.035
Kilograms	Pounds	2.2
Metric tons	Tons	1.1

Converting Temperatures

Convert degrees Fahrenheit (F) to degrees Celsius (C) by following this simple formula: Subtract 32 from the Fahrenheit temperature reading. Then mulitply that number by 5/9. For example, 77°F - 32 = 45. 45 × 5/9 = 25°C.

To convert degrees Celsius to degrees Fahrenheit, multiply the Celsius temperature reading by 9/5, then add 32. For example, 25° C × 9/5 = 45. 45 + 32 = 77°F.


Fahrenheit
Celsius
55°
50°
45°
40°
35°
30°
25°
20°
15°
10°
5°
0°
Freezing
25°
20°
15°
10°
5°
0°
-5°
-10°
-15°
-20°
-25°
-30°

Resources

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The Barefoot Beekeeper
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Master Gardener Program Handbook

IDAHO MASTER GARDENER
UNIVERSITY OF IDAHO EXTENSION

18th Edition

University of Idaho Extension

The *Idaho Master Gardener Program Handbook* was prepared by a committee of University of Idaho educators:

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December 2016

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- Homeowner Guide to Bees (BUL 854).....$4.00 (also online)
- Homeowner Guide to Minor Stinging Insects (BUL 853).....$4.00 (also online)
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Chapter 1
Introduction and Policies

INTRODUCTION

University of Idaho (UI) Extension's Idaho Master Gardener Program provides gardeners with opportunities to improve their horticultural knowledge and skills as well as to serve their communities. "Helping people grow" is the motto of the program. The program is conducted through participating UI Extension county offices under the direction of UI Extension educators.

Hundreds of Idaho Master Gardener™ volunteers give their time each year. Due to rapid urbanization in Idaho, training Master Gardeners is a critical element of extension education in Idaho. Master Gardener volunteers give time and effort to provide quality learning experiences, thereby improving the quality of life for Idaho's citizens. Volunteers also provide the important service of problem solving for issues related to gardening and landscaping. Idaho Master Gardeners are the second-largest volunteer group with which UI Extension works in Idaho (4-H is the largest).

To help Idaho Master Gardeners prepare for these roles, the University of Idaho's College of Agricultural and Life Sciences provides credit and certificate courses to prospective and active Idaho Master Gardeners across the state.

PURPOSE

The Idaho Master Gardener Program serves as an educational and volunteer organization. The program's purpose is to provide technical assistance and information in the area of home horticulture to people in all Idaho communities through qualified volunteers. UI Extension educators and specialists, staff, and volunteers share vision, ideas, and responsibilities for the program. However, ultimate responsibility for the Idaho Master Gardener Program is with the extension educators, who are accountable for operation of the program.

PROGRAM ADMINISTRATION

University of Idaho Extension

The Idaho Master Gardener Program is part of University of Idaho Extension, an educational resource partnership that extends research and technology to the people of Idaho as part of the university's land-grant mission. UI Extension, in turn, is administered within the University of Idaho College of Agricultural and Life Sciences, which is funded in part by the Agricultural Research and Extension Service appropriation from the Idaho legislature.

UI Extension helps people help themselves by bridging gaps between research and everyday problems. Areas of expertise are agriculture, community development, family and consumer sciences, natural resources, and youth development.

All UI Extension programs, including the Idaho Master Gardener Program, are administered through three extension districts in Idaho: northern, southern, and eastern. Many training events and volunteer opportunities are planned at the district level in collaboration with volunteers.

Funding

UI Extension is funded through a three-way partnership among local, state, and federal governments. In addition, volunteers, businesses, and private organizations contribute time, talent, and supplies.

Personnel

Idaho Master Gardener educational programs are conducted at the county level by University of Idaho Extension educators. These educators are members of the University of Idaho faculty. Educational materials and events are developed in cooperation with the Department of Plant, Soil and Entomological Sciences and other departments within the University of Idaho College of Agricultural and Life Sciences.

Extension educators are based in UI Extension offices in nearly every Idaho county and at the Fort Hall, Nez Perce, and Coeur d'Alene Indian reservations. The educators are supported by subject-matter specialists and researchers, also university faculty members, located at University of Idaho research and extension centers around the state and on the University of Idaho campus in Moscow.

Extension faculty and their support staff work with the people of Idaho to address agricultural, natural resource, youth, family, community, and environmental issues. Collaborative relationships with countless agencies, groups, and individuals make possible a vast array of innovative educational programs.

TRAINING AND CERTIFICATION POLICIES

Requirements for becoming a certified Idaho Master Gardener and for maintaining certification are detailed below. The listed requirements are minimum statewide standards, and it should be understood that extension educators in some counties may have more stringent requirements for participation. This is a prerogative of the extension educator.

Initial training and certification

Idaho Master Gardeners

Becoming an Idaho Master Gardener involves a significant commitment of time and effort. Initially, applicants must receive at least 30 hours of basic education on a variety of topics related to plant science, landscaping, and urban horticulture. Individuals must receive a satisfactory grade on exams or demonstrate competency in the course content to the satisfaction of the program coordinator.

Following the basic training course, and within a 6-month to 1-year period (timing may vary by county, course schedule, and extension educator preference), an additional minimum of 30 hours of practicum/hands-on training and directed volunteer service must be completed. The type of hands-on training is based on a mutual decision between the supervising UI Extension educator and the Idaho Master Gardener trainee. At least part of the service hours must be spent in or arranged through the county extension office.

The applicant will receive certification as an Idaho Master Gardener upon successful completion of the Idaho Master Gardener Program classroom instruction, examinations, and hands-on training, including completion of volunteer hours. Certificates and identification badges that verify program status and satisfactory program completion are provided at the discretion of each responsible county extension educator.

Certification as an Idaho Master Gardener is valid for 1 year only.

Advanced Idaho Master Gardeners

Many Idaho counties offer the opportunity to become an Advanced Idaho Master Gardener by participating in specific, advanced-level training. The process of qualifying as an Advanced Idaho Master Gardener can vary widely by county, and volunteers should seek advice from the local coordinator to determine requirements. Certification as an Advanced Idaho Master Gardener is valid for 1 year, and continuous recertification is required to maintain status.

Continuing certification

Idaho Master Gardeners

To maintain Idaho Master Gardener certification in years subsequent to initial training, a volunteer must complete a minimum 3 hours of education/training and 7 hours of service every 12 months. If these requirements for training and service are not met, recertification will not be issued. See "Time away from recertification" for policies on becoming recertified.

Advanced Idaho Master Gardeners

Individuals may retain Advanced Idaho Master Gardener status by completing a minimum of 10 hours training plus 10 hours volunteer service every

12 months. Extension educators at some locations may require more hours or have additional requirements.

Time away from recertification

Any person missing recertification for 1or 2 years may again become a certified Idaho Master Gardener or Advanced Idaho Master Gardener by completing the annual recertification requirements without additional training or testing. Any person who misses recertification for 3 consecutive years must take a closed-book recertification exam and obtain a minimum score of 70 percent. The person may take the exam only once. If the person fails to attain a score of at least 70 percent, he/she must retake the 30-hour basic training course and complete the 30 hours of hands-on training and directed volunteer service to be certified as an Idaho Master Gardener.

Transferring Master Gardener status

From another state

Individuals previously trained as a Master Gardener in another state may seek to become Idaho Master Gardeners. They must first provide a letter of recommendation from their previous county or state Master Gardener program coordinator. In addition, they must schedule an entrance interview with the UI Extension educator or program coordinator responsible for the Idaho Master Gardener Program in their county. In the interview they will mutually agree to the necessary training to be certified in the Idaho Master Gardener Program.

From another Idaho county

Idaho Master Gardeners who move to a new county within the state will retain their certification but may be required by the extension educator in the new location to participate in additional training before serving as a volunteer within that county. Advanced Idaho Master Gardeners must meet the training requirements of the new county before being granted active status.

Idaho Master Gardener emeritus

Purpose

The purpose of Idaho Master Gardener emeritus status is to recognize and keep exceptional volunteers involved in the program. Emeritus status is intended to be awarded to an Idaho Master Gardener who has given exemplary service over the years, beyond the basic requirements to maintain certification, but is no longer able to meet all recertification requirements or participate fully in the program due to time constraints or health issues. Emeritus status may also be given posthumously to an exceptional Idaho Master Gardener Program volunteer.

Privileges

- Maintains Idaho Master Gardener certification by completing a minimum of 5 hours of hands-on service and/or education per year
- No longer is required to pay Idaho Master Gardener Program class fees but may attend any and all classes offered
- Has full use of resources in the University of Idaho Extension office
- Maintains membership in local Idaho Master Gardener associations with the payment of dues reduced or eliminated, at the discretion of the organization

Eligibility

- Has served for at least 10 years as an Idaho Master Gardener and volunteered for at least 500 hours
- Is an exemplary active participant in the local Idaho Master Gardener Program
- Has supervised a significant number of horticulture community projects or taught a significant number of horticulture classes to the general public and/or assisted in teaching Idaho Master Gardener Program classes
- Has been an active contributing Idaho Master Gardener in solving horticultural problems for the general public through the extension office (for example, through a plant diagnostic clinic)

Nomination process

- No more than two persons per year per county may receive emeritus status. Emeritus status does not have to be awarded every year, but only as needed.
- A letter of nomination is sent to the University of Idaho Emeritus Committee in the county by any active Idaho Master Gardener, extension educator, or program coordinator. An emeritus committee member may also nominate an Idaho Master Gardener for emeritus status. No emeritus committee member may be nominated for the award during his or her term on the committee.

- A report summarizing all past work and hours completed by the nominee must be turned in to, or completed by, the emeritus committee as part of the nomination process.
- The decision to award emeritus status is made by the emeritus committee in the county. The committee will consist of the extension educator coordinating the Idaho Master Gardener Program in the county and two or three active Idaho Master Gardeners chosen by the extension educator. Membership on the emeritus committee may last no more than 3 years.

Training of trade-related professionals

Industry professionals are welcome to extend or supplement their knowledge and credentials through University of Idaho classes and certification programs, including the Idaho Master Gardener Program. However, professionals must recognize that the Master Gardener course is specifically designed to train active volunteers. If a trade professional knows up front that providing volunteer service is not feasible, reimbursement for training and materials or in-kind support of the program will need to be negotiated with the extension educator. Also, because this is a volunteer training program, the supervising extension educator may rightfully accept only a limited number of trade applicants in any one training session.

Upon completion of the course, trade applicants should exercise proper business ethics by not utilizing their Idaho Master Gardener status to directly enhance their business opportunities. Additionally, it is considered inappropriate to solicit for personal or business purposes at or during University of Idaho Extension volunteer meetings, training sessions, or other functions.

APPLICATION AND TRAINING PROCEDURES

Application and volunteer position description

Before beginning training, each applicant must complete and sign an Idaho Master Gardener Program application and an opportunity contract (included at the end of this chapter). Before taking part in any volunteer service, either as a trainee or as a certified Idaho Master Gardener, each individual must also read and sign an Idaho Master Gardener Program authorized volunteer position description (included at the end of this chapter). The position description outlines the requirements of the volunteer position and the methods of supervision. The position description is also required to activate University of Idaho liability insurance for the volunteer. Position descriptions will be kept on file in the county extension office.

Fees

Fees vary from county to county based on the needs of the local program. Fees may be used to cover the cost of the Idaho Master Gardener Program Handbook, materials and resources for the classes, lab supplies, tours, and field trips.

Training dates and locations

Contact your local University of Idaho Extension office for specific times, dates, and locations for Idaho Master Gardener training. In most counties training begins in January and ends in April or May. However, some counties offer summer or fall courses.

Master Gardener training outside the county of residence

In any given year, Master Gardener training is offered in approximately 20 of the 44 Idaho counties. Many extension educators serve multiple counties, including those that do not maintain Master Gardener volunteer programs. In the case of multi-county programs, Idaho Master Gardeners may be required to perform at least part of their volunteer service in the county wherein they were initially trained. The volunteer may discuss arrangements, prior to submitting an application for training, to serve partly or wholly in the county where they reside. It is important to recognize that each county program is unique and has different resources available to implement the Master Gardener program, and volunteer situations may not always be ideal.

College credit

Applicants accepted into the Idaho Master Gardener Program may, for an additional fee, obtain college credit from the University of Idaho College of Agricultural and Life Sciences. Up to three credits can be earned. Extra classwork and/or practicum work may be required for a satisfactory grade. Contact your local UI Extension office for more information about this opportunity.

ADDITIONAL PROGRAM POLICIES

Volunteer activity record

UI Extension requires an accounting of volunteer hours and tasks for all Idaho Master Gardeners and trainees. An activity log provides legal protection for the volunteer while in the course of service. It also allows the local coordinator to provide credit for volunteer service and measure the effectiveness of the program. Use the volunteer activity record (available at the end of this chapter) to keep track of your volunteer hours, activities, and contacts. "Hours" is the total number of hours a volunteer has spent on Idaho Master Gardener activities. "Contacts" refers to the number of people the volunteer assists.

Impact and accountability

Master Gardeners plan and implement numerous countywide community projects. It is very important that they document the inputs, outputs, and outcomes of their projects, tasks, and assignments. Accountability should be one of the important factors in all phases of communication, planning, implementation, and evaluation of their projects.

Reimbursement for expenses

Idaho Master Gardeners share their knowledge free of charge with individuals, groups, schools or in community service roles but may accept reimbursement for mileage and materials.

Liability coverage

For trainees

Only authorized volunteers are entitled to the protection of the University of Idaho's liability coverage program. As a rule, during the required 30 hours of coursework, a Master Gardener trainee is not an authorized volunteer and therefore not covered by the university's liability insurance program. Prior to beginning coursework, applicants must read and sign an acknowledgement of risk and waiver of liability (available at the end of this chapter). If a trainee desires to participate in authorized volunteer service before the completion of coursework, he or she must get the approval of the appropriate extension educator and fill out an Idaho Master Gardener Program authorized volunteer position description.

For authorized volunteers

Prior to starting the 30 hours of hands-on training necessary for certification as an Idaho Master Gardener, each trainee must complete the authorized volunteer position description in preparation for becoming an authorized volunteer. It should be recognized that becoming an authorized volunteer is not the same as becoming a certified Idaho Master Gardener. Authorized volunteers are persons who have been directed and given permission, in writing, to perform a specific function by a University of Idaho employee with the authority to recruit assistance. The volunteer is then protected while acting within the scope and course of this authorized volunteer service.

The liability coverage program will respond to a claim against a volunteer if the university is able to document that the person was an authorized volunteer acting within the scope and course of the requested service and during the time they were volunteering. Documentation for an authorized volunteer should include:

1. A completed authorized volunteer position description on file. The position description needs to specifically state the duties for which the volunteer is responsible.
2. A log of the volunteer's hours, based on the volunteer activity record that is maintained by a university employee at the local county office.

Workers' compensation coverage

Workers' compensation coverage is provided by the Idaho State Insurance Fund for all employees. Authorized volunteers, such as Idaho Master Gardeners, may be eligible for workers' compensation coverage, which is decided on a case-by-case basis by state insurance fund claims adjudicators. To present a claim, it is vital that the university have on file a completed authorized volunteer position description and an up-to-date volunteer activity record. The claim adjudicator will want to establish that the volunteer's duties were authorized, that he or she was working within the established course and scope of his or her duties, and that he or she was "on the job" at the time of the potential workers' compensation incident.

Vehicle coverage

When an authorized volunteer uses a privately owned vehicle for official university business, the privately owned vehicle's liability and physical damage insurance is primary and the University of Idaho's liability insurance is secondary, up to the limits of the Idaho Tort Claims Act. Individuals should check with their own insurance agent to determine coverage on their privately owned vehicle when used for business purposes.

Prior to being authorized to use a University of Idaho vehicle, each authorized volunteer Idaho Master Gardener must become a "qualified driver." To become a qualified driver of a university vehicle, Master Gardeners must participate in a training course as defined in the *University of Idaho Administrative Procedures Manual*, chapter 5.

Working with youth

Idaho Master Gardener volunteers may have opportunities to work with youth in school programs or in 4-H or other youth organizations. In order to work with youth, all UI Extension volunteers, including Idaho Master Gardeners, must first go through an approval process, which includes a criminal background check, interview, and reference check. Until a volunteer has successfully completed the screening process, he or she should do no volunteer activities that involve working with youth unless a person authorized to supervise youth is present. For example, a volunteer may teach youth in a public school if the teacher of the class is present. Even if a volunteer is authorized to work with youth, it is still advisable that a second adult be present.

Civil rights and diversity

The University of Idaho has the following nondiscrimination policy:

"The University of Idaho has a policy of nondiscrimination on the basis of race, color, religion, national origin, sex, sexual orientation, gender identity/expression, age, disability or status as a Vietnam-era veteran. This policy applies to all programs, services, and facilities, and includes, but is not limited to, applications, admissions, access to programs and services, and employment."

In addition, discrimination is prohibited across the nationwide Cooperative Extension System in programs and with respect to individuals, audiences, groups, and organizations.

Idaho Master Gardeners, as representatives of UI Extension, are bound by this same policy. Idaho Master Gardener volunteers must make every effort to avoid discrimination in the form of either commission (purposefully excluding groups or individuals) or omission (adopting practices that inadvertently give preference) within the scope of their volunteer service. As a routine practice, Idaho Master Gardener volunteers should find creative ways to include underserved audiences.

Making recommendations—Providing accurate information

Whether through phone calls, home visits, plant clinics, presentations, newsletters, e-mails, websites, or other efforts, the information provided by Idaho Master Gardener volunteers must be unbiased and research-based. It must be accurate, current, and, when possible, taken from University of Idaho publications and research. Our mandated focus and emphasis is to extend to the people of Idaho the information being developed at the University of Idaho or other land-grant universities.

Idaho Master Gardener volunteers should use tact when advising clients. Your responsibility as a representative of the University of Idaho is to be an objective source of information rather than a subjective proponent for a particular approach.

It often is necessary to locate and interpret printed and online references to answer a client's question. Look first to resources from University of Idaho Extension or from the extension services of universities in neighboring states as well as to authoritative reference texts or research papers written by university experts. These sources have passed through a rigorous review process for technical accuracy so can be used with confidence.

University of Idaho publications can be obtained at the local UI Extension office; by writing to Educational Publications Warehouse, University of Idaho, 875 Perimeter Drive MS 2332, Moscow, ID 83844-2332; by calling (208) 885-7982; by faxing (208) 885-4648; or by e-mailing calspubs@uidaho.edu. Many publications are available to download from http://www.cals.uidaho.edu/edComm/catalog.asp

As an Idaho Master Gardener, you may make recommendations about home horticulture, home vegetable and home fruit culture, ornamentals, turf, and tree and landscape care. Do not make recommendations in areas within which you lack knowledge or experience. Refer questions related to the commercial nursery industry or commercial farm crops to the UI Extension educator in your county or to the appropriate UI Extension specialist.

Making pest management recommendations

When appropriate, provide clients with recommendations about pesticides and alternatives to pesticides so they can choose the best option for themselves. Often there is more than one solution to a pest problem; sometimes there is no simple solution. Pest problems not specifically covered by University of Idaho recommendations and that do *not* involve pesticide applications may be handled by suggesting treatments that an experienced Idaho Master Gardener considers appropriate.

Scope of responsibilities

Idaho Master Gardeners are authorized to make pesticide recommendations only for yard and garden pests, including pests of indoor houseplants.

- Do not advise homeowners with questions about other household pest control, such as pantry insects, structural pests, or crawling invading insects.
- Never advise anyone about pesticides for any commercial agricultural, horticultural, or landscape planting; this restriction includes, but is not limited to, commercial field and row crops, landscape nurseries, forest lands, and public recreation sites. State law requires that people making pesticide recommendations for commercial operations be certified and licensed as a pesticide applicator by the State of Idaho.
- Do not answer questions about pesticide liability issues. Direct all such questions to the UI Extension educator for further referral and action.
- Do not make pesticide recommendations to clients on behalf of the University of Idaho until you have satisfied each of the following three steps:
  1. Successfully completed Idaho Master Gardener Program training
  2. Successfully completed an additional training module specific to pesticides
  3. Signed and filed the pest management agreement (located at the end of this chapter)

Master Gardener coordinators will ensure that all Idaho Master Gardeners working under their supervision complete steps 1 through 3 above, keeping the signed pest management agreement form on file as a permanent record.

Recommending registered pesticides

When making pesticide recommendations as an Idaho Master Gardener, both you personally and the University of Idaho will be protected from potential liability issues if you satisfy these two conditions:

1. You recommend a pesticide legally registered and labeled for use in the yard or garden (or for indoor houseplants). The specific plant or site for application must be listed on the label. It violates federal and state law to apply a pesticide to a plant or site not listed on the label.[1]
2. The advice you give about how to use the pesticide is exactly as the pesticide label requires.

Be careful to note the directions for use, including application rates, timing, and frequency; pre-harvest and re-entry waiting periods; personal protective equipment; and product and container disposal. As a general practice, the specific target pest also should be listed on the label, but this is not required by state and federal law.

[1] Idaho State law, Title 22, Chapter 34 (pesticide law) specifically states:
No person shall:
(1) Use a pesticide in a manner inconsistent with its labeling except as provided for by rule.
(2) Make pesticide recommendations in a manner inconsistent with its labeling except as provided for by rule.
(3) Make false or misleading claims through any media relating to the effect of pesticides or application methods to be utilized.

Federal pesticide law[2] does allow these three exceptions about using pesticides in ways not stated on the label:

1. It is legal to apply less than the rate stated on the label (for example, the label advises 1 lb, so it is legal to apply less than 1 lb).
2. It is legal to apply less frequently than stated on label (for example, the label says apply every 7 days, so it is legal to apply every 8th or 9th day or longer period, as long as the pre-harvest interval is followed).
3. It is legal to apply a pesticide for a pest not listed on the label as long as the plant or application site is listed on the label (for example, the label says the product can be used for beetles on cabbage, so it is legal to apply for caterpillars on cabbage even though the label does not mention caterpillars).

Idaho Master Gardeners may recommend any of these three exceptions but first must confer with the UI Extension educator or a UI Extension specialist to ensure the advice is technically sound. This requirement to confer with a University of Idaho expert is especially true when recommending pesticides for pests not cited on the label; your specific pest deliberately may have been excluded from the label because the product does not work against that species. So while these three exceptions are permitted, in general the best practice is to not deviate in any way from label directions. You never will make a mistake if your recommendation exactly agrees with the label.

As an Idaho Master Gardener volunteer, you should make good-faith pesticide recommendations that are based on information directly from the pesticide label or already recommended by University of Idaho research and extension faculty or their peers at other regional universities, especially those in the Pacific Northwest and Intermountain West. Faculty expert recommendations appear in the annually updated, three-volume Pacific Northwest pest management handbooks as well as in Current Information Series publications and bulletins published by UI Extension. It is always a good practice to inform every client that the actual pesticide label always takes precedence over any oral or written recommendation.

Do not endorse any particular pesticide brand name, business, or service. Your mission as a representative of UI Extension is to be an objective source of information and knowledge that is not biased in any way. For example, rather than recommend a homeowner use RoundUp weed killer, you instead would advise use of products containing the active ingredient glyphosate and then give commercial trade names (like RoundUp, KleenUp, Eliminator Weed and Grass Killer) of locally available products. This approach does not imply endorsement.

Recommending household chemicals, homemade pesticides, and related tactics

Home chemicals. Never recommend any household cleaning product or other home chemical for pest control unless the product label specifically states it can be used to control or repel pests on your exact application site against your particular target pest. Only recommend pesticides specifically tested and approved by the Idaho State Department of Agriculture and/or the U.S. Environmental Protection Agency for your particular pest situation.

Homemade pesticides. Never recommend any recipe for homemade pesticides, regardless of how low risk it might seem or the presumed authoritative knowledge of the reference. You might unwittingly recommend a compound that physiologically damages the plant rather than protect it from pests, or, even worse, the homemade mixture might pose a real health risk to the homeowner, pets, or wildlife.

Homemade devices. You may recommend use of homemade physical and mechanical devices such as sticky boards that trap aphids or slug traps baited with beer. Devices and related physical control actions, such as using a garden hose to forcefully spray off aphids from sturdy landscape plants or killing weeds with steaming-hot water, are not considered pesticides by state and federal law and so are not subject to the Idaho Master Gardener Program pesticide policy. But, as always, base your advice on trusted, research-documented reference materials as supplemented by the knowledge and observations of an experienced Idaho Master Gardener.

[2] Federal Insecticide Fungicide Rodenticide Act section 2ee (FIFRA 2ee)

Making fertilizer recommendations

Fertilizer recommendations do not require state certification or licensing. When making fertilizer recommendations, use University of Idaho recommendations or those on the label of the product being used. Cultural problems not specifically covered by University of Idaho recommendations and that do not involve pesticide applications may be handled by suggesting treatments that an experienced Idaho Master Gardener considers appropriate.

Use of title and logo

The title Idaho Master Gardener™ and derivatives thereof are trademarked to the University of Idaho and are to be used only and exclusively in association with University of Idaho Extension's Idaho Master Gardener Program and not for commercial purposes. Idaho Master Gardeners should not display credentials or use their title to advance their business interests or a personal agenda. Persons are expected to identify themselves as participants in the Idaho Master Gardener Program only when performing volunteer work affiliated with the program. The training, experience, and certification gained in the Idaho Master Gardener Program may be used and listed as qualifications when seeking employment.

Additionally, the Idaho Master Gardener Program logo, letterhead, and other brand elements must not be used for advertising or any other purpose outside the activities of the program. All volunteers are expected to help maintain the integrity of the Idaho Master Gardener Program.

Idaho Master Gardener associations

Membership and supervision

Idaho Master Gardener associations are county-based associations formed at the discretion of the UI Extension educator. People who are certified Idaho Master Gardeners may belong to a county-based Idaho Master Gardener association. Operation of the association is under the direct supervision of a UI Extension educator or Idaho Master Gardener Program coordinator.

Purpose

Following are the purposes of a county Idaho Master Gardener association:

- Enhance the overall benefits of the Idaho Master Gardener Program in local communities
- Provide ongoing education to help people maintain their Idaho Master Gardener certification
- Develop educational programs to be delivered to citizens in the county to supplement the University of Idaho home horticulture program
- Provide camaraderie for individuals with similar interests and purposes

Association income, bank accounts

There may be a need to have a source of income to enhance the educational efforts of the Idaho Master Gardener association. The association may charge dues if so desired and/or raise money by other means such as plant sales. Money may be held in a local county UI Extension office account if allowed by the county or be deposited in a separate bank account with a unique taxpayer identification number. No money shall be held in the name of an individual (see *County Operations Handbook*, section B-3, for complete information on proper money handling procedures). Idaho Master Gardener associations with 501(c)(3) status are still accountable to the University of Idaho, as the association funds are generated while individuals are volunteering under the supervision of the university.

Unaffiliated associations

People who are currently certified as Idaho Master Gardeners or who have been certified are not prohibited from forming associations that are separate from the University of Idaho, but these associations will not be recognized by the University of Idaho and their members are prohibited from conducting educational programs under the auspices of the Idaho Master Gardener Program or the University of Idaho and must not refer to the independent association as an Idaho Master Gardener association. Furthermore, if such an association is formed, members must not use the title Idaho Master Gardener or derivatives thereof. If an association organized under the guidance of the university later separates from it, all funds in an account at the time of separation belong to the University of Idaho.

Role of UI Extension educator in Idaho Master Gardener associations

A University of Idaho extension educator is responsible for the Idaho Master Gardener Program within an assigned county or area and for the operation and function of its Idaho Master Gardener association. Duties of a UI Extension educator working with its county association include:

- Coordinate an Idaho Master Gardener volunteer training program to certify volunteers
- Preapprove all volunteer projects for noncertified volunteers who have completed the coursework and are seeking Idaho Master Gardener certification. A UI Extension educator will approve only those volunteer projects that contain an element of education for the recipients; the information presented must be from the University of Idaho, another university, or some other reliable research-based source.
- Assist certified Idaho Master Gardeners to develop projects, if needed
- Projects such as workshops, short courses, community gardens, etc., developed by certified Idaho Master Gardeners need to be preapproved by the extension educator; however, a simple request for an educational presentation by a group does not need preapproval (for example, a request by a local garden club for a presentation on pruning roses). Projects must contain an element of education for the recipients, and the information presented must be from the University of Idaho, another university, or some other reliable research-based source.
- Approve or provide additional training needed by volunteers to maintain their Idaho Master Gardener certification
- Meet with association members on a regular basis
- Assist Idaho Master Gardener volunteers to develop educational projects that are beneficial to the citizens of their county

Responsibilities of Idaho Master Gardener association members

An Idaho Master Gardener association will be more successful if all members take an active role. Just as a UI Extension educator has a responsibility to the association, its members should assume the following responsibilities:

- Help develop and deliver educational programs for citizens in the county to supplement the Idaho Master Gardener and home horticulture programs
- Assist in developing and delivering educational programs for members of the association
- Work to enhance the overall benefits of the Idaho Master Gardener Program to all citizens in the county
- Mentor individuals seeking to become Idaho Master Gardeners
- Work cooperatively with the UI Extension educator or program coordinator
- Be certain that all volunteer projects counting toward Idaho Master Gardener recertification contain an element of education for the recipients and that the information presented is from the University of Idaho, another university, or some other reliable research-based source
- Follow University of Idaho nondiscrimination policies

BEING AN IDAHO MASTER GARDENER VOLUNTEER

Volunteer service opportunities

Idaho Master Gardeners assist in many areas of the community through demonstration gardens, horticulture classes, information booths, and UI Extension offices. Below is a list of some service opportunities in which Idaho Master Gardeners may be involved:

- Presenting educational programs/demonstrations on gardening to adults
- Helping at gardening education events: workshops, clinics, trade shows
- Presenting gardening classes to school youth
- Working at 4-H plant science events or training sessions
- Staffing information booths at fairs, field days, and horticultural education events

- Helping teach Idaho Master Gardener classes
- Reading gardening articles and summarizing them for Idaho Master Gardeners and extension educators
- Writing newsletters and information sheets on gardening
- Maintaining a website for the county's Idaho Master Gardener Program
- Organizing Idaho Master Gardener plant clinics
- Making garden or landscape site visits
- Organizing community service projects related to gardening, including landscape design and maintenance
- Organizing an Idaho Master Gardener mentoring program for the county
- Answering garden calls at home or at the county's UI Extension office

Volunteer service guidelines

Idaho Master Gardeners represent the University of Idaho. Accurate and quality work is expected. These guidelines are basic for any professional, whether volunteer or paid:

- Be punctual, trustworthy, and reliable. Follow through with your commitments and responsibilities. Call if you will be delayed or cannot be there.
- Maintain a friendly, warm, courteous attitude toward the public.
- Communicate effectively with clients, staff, fellow volunteers, and University of Idaho faculty members. Be a capable and positive team member.
- Freely cooperate with the volunteers of other UI Extension volunteer programs. We are all on the same team.
- Learn as much as possible about your volunteer assignment and take the time to ask appropriate questions before beginning a task.
- Accuracy is important and greatly appreciated.
- Dress appropriately for the volunteer activity in which you are involved, paying particular attention to safety.
- Make child care arrangements for the time you have committed to work as a volunteer. In some cases, it is not appropriate for safety or security reasons to bring children to certain events or activities.
- Follow UI Extension affirmative action policies, which forbid discrimination against anyone because of their race, color, gender, national origin, religion, age, sexual orientation, or disability.
- Enjoy your volunteer time. Volunteering is rewarding and satisfying.

Termination of volunteer services

As an Idaho Master Gardener volunteer, you are a representative of University of Idaho Extension and as such have agreed to abide by its policies and expectations. If your behavior is not acceptable or not in the best interests of UI Extension, the volunteer program, or our clientele, you may be reprimanded or asked to leave the program.

The following behaviors observed at or on the premises of any program or function, or while you are acting as a UI Extension volunteer, will not be tolerated:

- Criminal acts
- Profanity
- Illegal or inappropriate use of mind-altering substances (alcohol or drugs)
- Harassment
- Discrimination
- Abuse of any kind toward a fellow human

The above actions may constitute cause for disciplinary action or immediate dismissal.

Volunteer benefits

As an Idaho Master Gardener volunteer, you have many benefits. One major benefit is becoming part of a national volunteer network. You are part of the UI Extension network and have access to all of the information resources of that system. As a volunteer you will have the satisfaction of being a valuable resource to others.

Networking is another benefit that includes your fellow Idaho Master Gardeners and the faculty and staff of research facilities belonging to the University of Idaho. Tours of plant science facilities on campus and at any of the research and extension centers can be arranged. This networking benefit also extends to other volunteers such as 4-H leaders or food safety advisors. Another benefit is reduced

prices or free admittance to seminars, classes, and workshops that need volunteer help.

Idaho Master Gardener volunteers benefit by increasing their leadership, organizational, decision-making, and problem-solving skills. As a testimony to the positive benefits of Master Gardener service, experienced volunteers report that they have made lasting friendships, increased their public relations skills, become more effective at work or home, and been well prepared for new employment or other volunteer opportunities.

UI Extension educators and staff benefit from association with Idaho Master Gardener volunteers by acquiring fresh, new ideas, acquiring an increased understanding of their community and clientele, and gaining the ability to reach a vastly increased audience. Given limited UI Extension resources and the increasingly urban population of the state, this last benefit is very important.

Every 2 years there is an international Master Gardener conference. You are eligible to join the national and international Master Gardener organizations as a certified Idaho Master Gardener. In most even years a western regional Master Gardener conference is held, which is a source of great ideas to bring back to your communities. A regional Idaho Master Gardener conference is held each year in one of the three regions of the state (northern, southern, and eastern). Take advantage of these opportunities and ask at your UI Extension office for conference information.

Last but not least, there are certain tax benefits to volunteers who itemize state and federal income tax returns. Since these may change annually, you will need to update which kinds of expenses are deductible and which are not. Consult your tax accountant for allowable deductions.

Importance of volunteers

Each volunteer is vital to the success of our program, no matter what kind of volunteer work they do. There is no such thing as a small or unimportant job. Each individual brings skills that are unique and special, that really add to the educational effort. Each Idaho Master Gardener is a valuable part of our team.

Each year counties try to recognize the special things volunteers have done or accomplished in service to their communities. By itself, the Idaho Master Gardener name badge is recognition of your educational accomplishment. Wear it with pride. You are important to us!

University of Idaho Extension

Idaho Master Gardener™ Program

AUTHORIZED VOLUNTEER POSITION DESCRIPTION

Purpose of the Idaho Master Gardener Program

To extend horticultural education through trained and certified volunteers.

Brief description of Master Gardener volunteer responsibilities

Volunteers are to provide education and assistance to Idaho residents in topic areas related to home horticulture. Activities may include, but are not limited to, answering questions in person and over the telephone about vegetable gardening, fruit trees, ornamentals, lawns, insects, and other related topics; assisting with public horticulture projects; assisting in the preparation of home horticulture classes; and organizing special seminars and conferences for homeowners and other Master Gardeners.

Requirements for volunteer service

- Have an interest and/or knowledge or skills in basic gardening, ornamental horticulture, or general plant-related topics.
- Be able to communicate effectively with the public.
- Have completed or be enrolled in beginning Master Gardener classroom training (a minimum of 30 hours).
- Read and agree to the terms of the Idaho Master Gardener Program authorized volunteer position description and complete and sign the opportunity contract.
- Have completed or be enrolled in additional hands-on practicum training and volunteer service (a minimum of 30 hours) during the initial training to become a certified Idaho Master Gardener under the direction of a University of Idaho Extension educator.
- Be responsible to the extension educator in charge of the Idaho Master Gardener Program. All outside projects must be preapproved, except that a simple request for delivery of an educational presentation by an Idaho Master Gardener to a group does not need preapproval. Outside projects must contain an element of education and follow all University of Idaho guidelines using information from the University of Idaho, another university, or some other reliable research-based source.
- Adhere to University of Idaho horticulture recommendations and cooperate with the county extension staff.
- Be in the process to complete, or have completed, all statwide and local requirements for certification as an Idaho Master Gardener.
- Follow University of Idaho nondiscrimination policies.
- If required to operate a University of Idaho vehicle as part of volunteer duties, be trained as a qualified driver.

Supervision of volunteers

- The University of Idaho Extension educator in charge of the Master Gardener program provides supervision and educational support to the volunteer Master Gardener.
- The extension educator will assign, review, and assess hands-on practicum work for the Master Gardener trainee.
- The extension educator will review and assess volunteer projects for certified Idaho Master Gardener and Advanced Idaho Master Gardener volunteers.
- The extension educator will provide in-service training and furnish space and other needed support materials when the Master Gardener volunteer works in the extension office.

Signed: Idaho Master Gardener Volunteer _____ Date _____

Signed: County Master Gardener Supervisor _____ Date _____

University of Idaho Extension

Idaho Master Gardener™ Program

APPLICATION

I would like to be considered for University of Idaho Extension's Idaho Master Gardener Program. I understand that, if accepted, I am required to complete a minimum of 60 hours of training (30 hours of basic education and 30 hours of hands-on training and directed volunteer service). The hands-on training must be completed within 6 months to 1 year of completing the classroom portion of the course (dependent on local county policy), unless prior arrangements are made with the UI Extension educator in charge.

All applicants should consider the expectations of Idaho Master Gardener service. Following certification, all Idaho Master Gardeners are committed to provide volunteer service for as long as they remain certified. Participants who are unable to participate in volunteer service after becoming certified should not sign up for the Idaho Master Gardener Program.

Name (please print) Date

Address Zip Code

Phone (day) Phone (evening)

Signature Date

How did you learn about the Idaho Master Gardener Program?

Years of gardening experience _____ Where have you gardened before moving here?

Have you ever been in a Master Gardener program in Idaho or another state? ☐ Yes ☐ No

If yes, indicate where and year(s)

Please list all horticultural education you have received (school, topics, and dates, if possible).

Please list your areas of specialization or interest (vegetables, roses, greenhouse, herbs, etc.).

Are you affiliated with any gardening clubs or horticulture-related groups? If so, please list.

Why do you wish to become an Idaho Master Gardener?

(continued)

University of Idaho Extension

Idaho Master Gardener Program

APPLICATION—PAGE 2

What do you expect from this class?

How might you use your volunteer time to help others in the community?

How would you rate your "people skills" (ability to work with others)?

☐ Excellent ☐ Good ☐ Fair

How would you rate your gardening skills?

☐ Expert ☐ Intermediate ☐ Beginner

Are you knowledgeable in growing any of the following? Please check all that apply.

☐ House plants	☐ Herbs	☐ Turf
☐ Vegetables	☐ Annual flowers	☐ Shrubs
☐ Tree fruits	☐ Perennial flowers	☐ Ground covers
☐ Berries	☐ Ornamental trees	☐ Other (specify) _____

How do you receive gardening information? Please check all that apply:

☐ Garden magazines	☐ Nursery/garden center personnel	☐ Family/friends/neighbors
☐ Newspaper articles	☐ University/college professors	☐ Garden clubs
☐ Extension bulletins	☐ Extension office staff	☐ Master Gardeners at extension office
☐ TV/cable stations	☐ Radio stations	☐ Internet

Are you employed now? ☐ Yes ☐ No ☐ Full-time ☐ Part-time

Are you retired? ☐ Yes ☐ No Semi-retired? ☐ Yes ☐ No

Do you speak a language other than English? ☐ Yes (language) _____ ☐ No

If certified as an Idaho Master Gardener, do you give permission to UI Extension to publish your picture without additional permission and with or without accompanying personal identification (your name)?

☐ Yes ☐ No

Check the skills you are good at:

☐ Public speaking	☐ Artistic
☐ Writing	☐ Manual labor
☐ Computing/web design	☐ Marketing/media work
☐ Typing, filing	☐ Other (specify) _____

I would like to take this class for ☐ Academic credit (an additional fee applies)

Return this form to the University of Idaho Extension office in your county.

At the University of Idaho we respect your right to privacy and we understand that participants need to be in control of their personal information. "Personal information" includes, but is not limited to, name, address, telephone number and e-mail address. The University of Idaho does not sell, rent, swap or otherwise disclose any of this information other than for the sole purpose of Civil Rights reporting.

University of Idaho Extension

Idaho Master Gardener™ Program

OPPORTUNITY CONTRACT

I wish to become an Idaho Master Gardener. I understand I must complete the classroom instruction, finish all quizzes and exams, complete all lab work, and complete volunteer hands-on training to become certified. I realize that part of my hands-on training hours must be spent at, or arranged through, the UI Extension office where I complete my training. I also understand that I can sign up for more than one hands-on project and volunteer more than the required number of hours.

If I am accepted into the Idaho Master Gardener training program and /or become certified as an Idaho Master Gardener, I will abide by all regulations and policies of University of Idaho Extension.

As a certified Idaho Master Gardener, I agree to provide University of Idaho pest control recommendations even if they include synthetic chemical pesticides. I also agree to become, or work under, a person licensed as an Idaho pesticide applicator.

I understand that as an Idaho Master Gardener, I am considered a volunteer representative of the University of Idaho. Therefore, the University of Idaho will assume liability for my pest control recommendations, but only if my recommendations are in accordance with the University of Idaho pesticide policies found in chapter 1 of the *Idaho Master Gardener Program Handbook*.

Name (please print) _____ Date _____

Address _____ Zip Code _____

Phone (day) _____ Phone (evening) _____

Signature _____ Date _____

All certified Idaho Master Gardeners are required to provide volunteer service. One important function is to assist the local county UI Extension educator in the office, answering horticulture-related inquiries in the spring and summer. Time commitments vary by county. Indicate the days and months that are convenient for you. You will be contacted for specific dates.

MONTH	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT/SUN
APRIL						
MAY						
JUNE						
JULY						
AUGUST						
SEPTEMBER						
OCTOBER						

☐ My schedule is flexible. I can be available almost anytime with advance notice.

I speak a language other than English. ☐ Yes (language _____) ☐ No

(continued)

University of Idaho Extension

Idaho Master Gardener Program

OPPORTUNITY CONTRACT—PAGE 2

Select several project areas of interest to you.

Plant Clinic

- ☐ Plant clinic (identifying plant problems)

Garden Projects

- ☐ City beautification
- ☐ 4-H/youth garden projects
- ☐ Weed/insect collection
- ☐ Demonstration garden
- ☐ Senior citizen garden project

Support Activities

- ☐ Artwork, calligraphy
- ☐ Photo album, photography

Communications/Writing

- ☐ Garden newsletter articles
- ☐ Newspaper articles
- ☐ Publicity for Idaho Master Gardener Program

Landscape Design/Maintenance

- ☐ Extension office landscape
- ☐ Other landscapes (must be approved by the Master Gardener coordinator)

Speaker's Bureau

- ☐ Speaker/presenter (topic) _____

  _____
  - ☐ For youth groups only
  - ☐ For adult groups only
  - ☐ Audience make-up is not crucial

Special Events

- ☐ Information booths
- ☐ Fundraising events
- ☐ Garden tours

Office Assistance

- ☐ Filing/organizing paperwork
- ☐ Typing, mailing, stapling, collating
- ☐ Telephone answering

Other

- ☐ Special project (topic) _____

  _____

Return this form to the University of Idaho Extension office in your county.

At the University of Idaho we respect your right to privacy and we understand that participants need to be in control of their personal information. "Personal information" includes, but is not limited to, name, address, telephone number and e-mail address. The University of Idaho does not sell, rent, swap or otherwise disclose any of this information other than for the sole purpose of Civil Rights reporting.

University of Idaho Extension

Idaho Master Gardener™ Program

VOLUNTEER ACTIVITY RECORD

Name (please print) Date

For program year Ending

Please complete this volunteer activity record each year of volunteer service and turn it in to your University of Idaho Extension office as directed by your program coordinator or extension educator. Please record specific accomplishments that you are most proud of on the back of this sheet. Let us know what you have done for your community!

If you need help filling out this form, please ask.

WHAT YOU DID AND WHEN			NUMBER OF CONTACTS MADE									
DATE	SUMMARY OF ACTIVITY	HOURS EARNED	MALE	FEMALE	ADULT	YOUTH	W	N	H	A	B	HC

Codes: W= Caucasian N = Native American H = Hispanic B = Black HC= Handicapped A = Asian

University of Idaho Extension

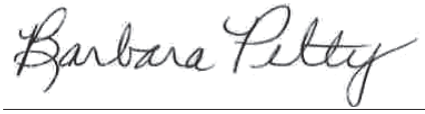
Idaho Master Gardener™ Program

TAX RECORDS FOR VOLUNTEER SERVICE

This certifies recognition of volunteer service performed within the University of Idaho's Idaho Master Gardener Program.

Idaho Master Gardener

Idaho Master Gardeners receive training from University of Idaho Extension educators in solving and giving advice on yard, garden, and houseplant problems. Volunteer service within this program is performed by Idaho Master Gardeners in various ways (e.g., participating in Master Gardener clinics, assisting in a county UI Extension office, speaking to groups, consulting on plant problems by telephone, and other methods arranged with UI Extension staff members).



Barbara Petty, Interim Director
University of Idaho Extension

Directions for claiming deductions: List the amount you claim as a deduction in Schedule A under "Contributions" (other than cash). This statement certifies that you have performed volunteer service. File this statement with your records. You should also keep a record of when and where your service was performed. Keep a record of mileage (read tax instructions to determine how many cents per mile are allowed). You may also list supplies you purchased and used within the Idaho Master Gardener Program. Keep this information with your records to verify your deductions in case your tax return is audited. Consult a tax accountant for advice as needed.

University of Idaho Extension

University of Idaho Extension

Idaho Master Gardener™ Program

EMERGENCY CONTACT FORM

College/Department

Activity Name | Date | Location

Name (First) | (Last)

Address

City | State | Zip

Phone (Cell) | (Home)

Primary Emergency Contact Name | Relationship

Phone (Cell) | (Home) | (Work)

Secondary Emergency Contact Name | Relationship

Phone (Cell) | (Home) | (Work)

PLEASE NOTE: Hospitals and clinics require Social Security numbers before providing treatment and suggest that participants bring a copy of their insurance card. **The participant is responsible for all medical expenses.**

The contact information provided will be shared only in the case of an emergency.

University of Idaho Extension

Idaho Master Gardener™ Program

PEST MANAGEMENT AGREEMENT

The role of pesticides is important for home yard and garden pest management recommendations. All pesticide use in Idaho is regulated by state and federal laws. In order to promote the safe and effective use of pesticides and reduce the misuse of pesticides, all University of Idaho volunteer Master Gardeners are required to follow the terms of this agreement, as listed below.

1. I must be a certified Idaho Master Gardener to give pest control advice to clients. Certification requires both successful completion of county Master Gardener training and requirements and successful completion of a pesticide online training course.
2. I can only advise homeowners about pesticide use around home yards, gardens and landscapes. Questions regarding commercial crop production, nursery management, forestry, public area landscape maintenance, aquatic weed management, and pesticide liability are to be referred to the county extension educator.
3. I will provide both chemical and nonchemical pest management recommendations allowing the client a choice of strategies.
4. I can only give pest management recommendations, both chemical and non-chemical, published in current University of Idaho or Pacific Northwest extension publications, in other university publications, or in some other reliable research-based source. Remember that the actual pesticide label always takes precedence over any oral or written recommendation.
5. I can only recommend pesticides that are registered for home and garden use. I must follow all label directions and precautions, including but not limited to: pre-harvest intervals, re-entry waiting periods, personal protective equipment, and product and container disposal.
6. I must never recommend any household product or chemical as a pesticide unless the product label states it can be used to control pests on the specific site of interest. I must never recommend any "homemade recipe" as a pesticide without proper labeling. Homemade insect or slug traps baited with food products are considered devices, and under state law, are not regulated as pesticides. If an Idaho Master Gardener has credible, published information from a university source on devices (for example, sticky boards that trap aphids or slug traps), they may be recommended.
7. I understand that as an Idaho Master Gardener, I am not required to have an Idaho pesticide license to recommend pesticides registered for home and garden use only.
8. I understand that as an Idaho Master Gardener, I am considered a volunteer representative of the University of Idaho. The university will assume liability for my pest management recommendations only if: (1) the pesticide is a legally registered product for home and garden use, (2) appropriate pesticide label directions and precautions are followed, (3) the management recommendations are made directly from the pesticide label or from current University of Idaho, Pacific Northwest extension, or other regional university publications, and (4) no household chemicals and/or homemade recipes are recommended unless they are labeled as pesticides.

Signed: Idaho Master Gardener Volunteer _____ Date _____

Print Name _____

University of Idaho Extension

Idaho Master Gardener™ Program

ACKNOWLEDGEMENT OF RISK AND WAIVER OF LIABILITY

Read this carefully and in its entirety. It is a binding legal document. **Sign and return this form** to your local Master Gardener coordinator or Extension educator. **If you are under the age of 18,** this form must be signed by you as the participant AND by your parent or legal guardian.

I, the undersigned participant or parent/guardian, am aware that participation in the Idaho Master Gardener Program ("Activity") may include activities that are risky and dangerous. Both participant and his/her parent(s) / guardian(s) ("I") acknowledge and accept the risks and give permission for my participation in the Activity. I acknowledge that participation in this Activity has the following non-exhaustive list of particular activities that **bear risk and danger and from which bodily injury to myself, or my child,** up to and including mortal injury, may occur: use, by me or others, of sharp instruments, pesticides, and herbicides; terrain which is in its natural state being unpredictable, unmaintained, or containing objects that are not visible; physical activities related to horticulture including, but not limited to lifting, bending, pulling, and pushing that involve strenuous exertion that could place stress on cardiovascular and/or musculo-skeletal systems and result in broken bones, strain, sprains, joint injuries, heart malfunctions, and head injuries; activities supplemental to the Activity, such as walking or hiking to and from sites of interest; use or operation, by me or others, of equipment and vehicles in the condition in which they are found; exposure to inclement weather including, but not limited to rain, sun, wind, snow, ice, and extremes of heat or cold; contact with dangerous animals, poisonous plants, insects and environmental or biological hazards; risks related to transit to or from the Activity locations including, but not limited to, travel by bus, van, and private or rented auto, including travel in unpredictable or extreme weather conditions that affect road; use of facilities, roads, sidewalks, parking lots, and trails that may or may not be properly maintained; exposure to contaminated food and untreated water; risk related to the rendering or receipt of emergency first aid, or other emergency treatment, and transport in medical emergencies; accident or illness in locations without access to appropriate medical facilities or supplies; and other unknown and unanticipated activities and risks.

In consideration of the University of Idaho ("UI") permitting me/my dependent to participate in the Activity, I and my dependent hereby voluntarily assume all risks associated with participation. To the extent permitted by law, I agree to indemnify, defend, save, hold harmless, discharge and release the State of Idaho, the Regents of the University of Idaho, their agents and employees from any and all liability, claims, causes of action or demands of any kind and nature whatsoever that may arise out of or in connection with my participation in any activities related to the above-named Activity. I understand I am responsible for all medical expenses and/ or property losses.

It is my express intent that this Acknowledgement of Risk and Waiver of Liability shall serve as a release, discharge and assumption of risk for my heirs, estate, executor, administrator, assigns and all members of my family.

I hereby certify that I am in good health and I know of no medical reason why I am not able to participate in the Activity. I have informed the Activity contact of any physical or medical condition that might expose me to an unusual risk of harm. I hereby consent to first aid, emergency medical care, and, if necessary,

This form continues on the back of this page. INITIAL PAGE 1 HERE: _____

ACKNOWLEDGEMENT OF RISK AND WAIVER OF LIABILITY—PAGE 2

admission to a hospital when necessary for administering such care, for treatment for injuries or illness that I may sustain while participating in the Activity. I accept and will abide by the University of Idaho Policies listed in the Policies and Information of Interest to Students brochure, which is available on-line at www.webs.uidaho.edu/riskmanagement or by contacting Risk Management at (208) 885-7177. I accept and will abide by the behavioral expectations of the Activity, and the policies and procedures of the University of Idaho.

Signed: Idaho Master Gardener Volunteer _____ Date _____

Print Name _____

Note: **If participant is under 18 years of age,** a parent/legal guardian must also sign and accept responsibility for the participant's actions and terms of the above agreement.

Signed: Parent or Legal Guardian _____ Date _____

Print Name of Parent or Legal Guardian _____

Published 1993. Revised 2012.

Chapter 2

INTRODUCTION TO HORTICULTURE AND PLANT PHYSIOLOGY

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Chapter 2
Introduction To Horticulture & Plant Physiology

Jo Ann Robbins, Extension Educator, Jerome County
Susan Bell, Extension Educator, Ada County

HORTICULTURE DEFINED

Horticulture is defined by Webster's dictionary as "the science and art of growing fruits, vegetables, and flowers." It is the intensive commercial production of high-value and high-yielding plants. But it also includes the cultivation of garden crops and landscape ornamentals and the interaction of science and art.

Horticulture contributes to the economy, provides good nutrition, and is a valuable spiritual and psychological therapy. Horticulture beautifies and enhances the environment. Areas of horticulture include the following:

- **Pomology**. Fruit culture, including pome fruits (apple, pear, quince), stone fruits (peach, cherry, plum, nectarine, apricot), small fruits (blueberry, raspberry, grape, strawberry), and nut tree fruits.
- **Vegetable production**. Culture of food crops from vegetable plants including roots, fruits, and seeds.
- **Floriculture**. Growing of cut flowers, potted plants, bedding plants, and bulbs and floral design.
- **Environmental horticulture**. Nursery production of herbaceous and woody plants for landscape design and management.
- **Postharvest physiology**. Harvest, handling, and storage of horticultural crops including flowers, fruits, and vegetables.

CLIMATE IN HORTICULTURE

Macroclimate

The term "climate" refers to the long-term weather patterns of a large geographical area and is used interchangeably with "macroclimate." Macroclimate is determined mainly by an area's latitude, elevation, nearness to large bodies of water, nearby ocean and wind currents, relation to nearby forests and irrigated areas, and location in relation to topographic features such as mountains.

Temperature and light are two fundamental features of climate that profoundly affect gardening. Rainfall, wind, hail, clouds, snow, and humidity also create the climate of a region. Short-term variations in rain, wind, snow, and other climatic characteristics are the weather.

Climatologists have calculated the statistical probabilities of certain climatic occurrences that are likely to affect plant growth. The USDA hardiness zone map, for example, is based on an area's average minimum temperatures. The Arbor Day Foundation has produced an updated version of the climate zone map based on the last 15 years of warmer temperatures (1990-2005) (figure 1).

Microclimate

Microclimates are variations in climate within a community, yard, or other restricted area and result from topographic features, soil types, aspect, or location of buildings, fences, and/or plantings. Different microclimates will be more or less conducive to different outdoor activities and will limit or enhance the success of plantings. For example, a shady northern exposure may make a better summer patio space than the sunny south side.

Gardeners can create or modify microclimates to increase livability and diversify planting conditions on their property. Landscape features that produce microclimates include the following:

- **Hills and low areas**. Hillside locations are less subject to frost since cold air is denser than warm air and will flow downhill to settle in low areas. A south-facing slope warms earlier in the spring than a north-facing slope, but will be hotter and dryer during summer. The leeward side of a ridge is less subject to wind or breeze than the windward side.

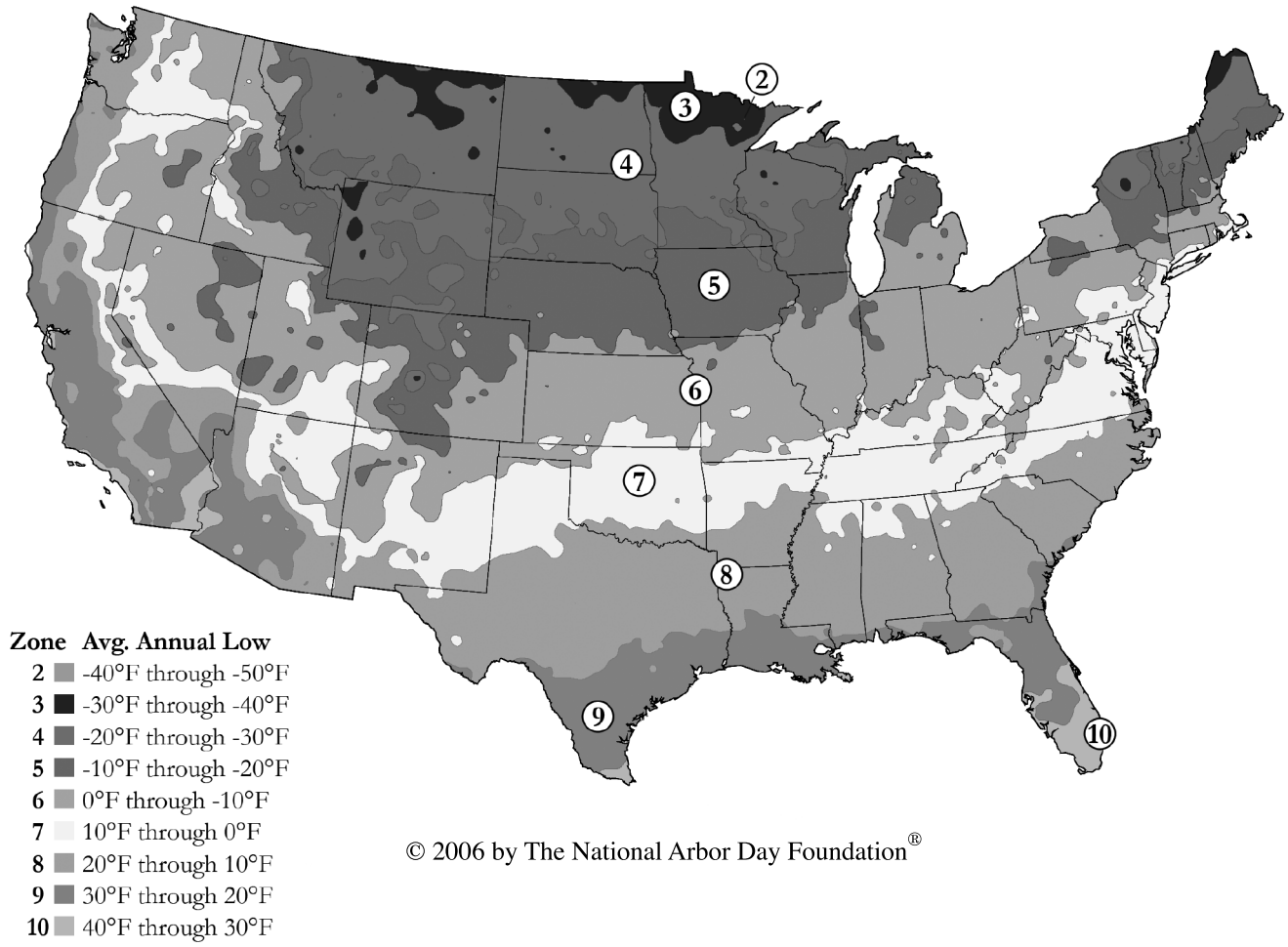


Figure 1. Hardiness zone map of the continental United States. Courtesy of the Arbor Day Foundation.

- **Structures**. Structures such as buildings, fences, driveways, or sidewalks serve as heat sinks for solar radiation. Planting areas around them will be warmer, especially on their southern sides or next to pavement. Northern sides of buildings and fences are shady and will remain cooler and moister.
- **Bodies of water**. Water has a moderating effect on air temperatures. A lot more energy is required to raise the temperature of water than the temperature of air. Likewise, water releases large amounts of heat energy when it cools. Thus, water acts as a buffer to heat or cold.

  Air blowing over cool water will cause adjacent land to warm up slower in the spring, thus delaying bloom and growth. This can protect plants from spring frosts. In the fall, air moving over warm water keeps the surrounding land warmer longer than areas farther away.
- **Elevation**. The higher the elevation, the cooler the temperature; there is less atmosphere to retain the heat from solar radiation at high elevations. Each 300-foot gain in elevation results in an average 1°F drop in temperature.
- **Raised beds**. Raised beds heat quicker than surrounding flat soil surfaces, but plants in raised beds may dry out faster and suffer root damage due to freezing in winter.
- **Plants**. Large plants create microclimates by reducing wind speed, creating shade, and raising the humidity beneath them.
- **Soil**. Sandy soil will warm more rapidly in the spring than clay soil and can be planted earlier, resulting in a crop that will mature more rapidly.

By identifying and using microclimates to your advantage, you can maximize the conditions for individual plants or strategically locate garden beds,



Figure 2. Soil, large objects, bodies of water, and large plants all create microclimates.

patios, and other outdoor spaces. The right microclimate often will make the difference between failure and survival for some landscape plants (figure 2).

ROLE OF TEMPERATURE IN HORTICULTURE

Temperature is the climatic factor that, more than any other, determines the kinds of plants that will grow in an area. Photosynthesis, transpiration, and respiration increase with rising temperature. Many horticultural crops thrive in warm climates such as California's and Florida's, but are challenged in northern climates like Idaho's. Cold temperatures restrict plant growth, freeze plants in mid-winter, and damage plants during fall and spring frosts. Surviving cold temperatures requires well-adapted plants. Hardiness is especially important for permanent landscape plants such as woody ornamentals and fruit trees.

Each plant type has an optimal temperature needed for growth. Some plants prefer cooler nights or days, whereas others prefer warmer nights or days. Temperate zone vegetables and annual flowers are classified as cool-season or warm-season crops. Cool-season crops (sweet peas, pansies, garden peas, onions, carrots, potatoes, lettuce, cabbage, and broccoli) grow best in the northern portions of the United States, at higher elevations, or during the spring and fall in warm-climate areas.

Warm-season crops (sweet corn, tomatoes, peppers, melons, zinnias, and marigolds) do best during the warmth of summer in the north but are ideally suited for growth over a longer season in warmer parts of the country. Seeds of warm-season crops require a soil temperature of 60°F or higher to germinate, whereas seeds of cool-season crops will germinate at a soil temperature of just 40°F.

High temperatures

Plant growth is measured by the food energy produced thorough photosynthesis above that used for respiration. Plants generally grow best at the higher end of their optimal temperature range. In the temperate zone, the minimum temperature for growth is about 40°F. Photosynthesis and respiration increase as temperatures rise until the energy used in respiration equals photosynthetic capacity, when growth ceases. For most plants, this temperature is around 96°F. For many cool-season crops, growth may cease at temperatures considerably lower than 96°F.

Warm temperatures cause stored carbohydrate reserves to be used up thorough respiration or to be converted to starch. This affects the sweetness of crops such as sweet corn and peas and thus their quality.

Very high temperatures can cause physiological damage to plants resulting in burnt leaves and slowed growth. Other high-temperature considerations in plant growth are discussed below.

Overcoming dormancy

Most temperate zone perennials need a cold period to overcome their physiological dormancy, or rest period, for either the entire plant or only for their flower and vegetative buds. Temperatures that are not cold enough during the winter will keep these plants from forming normal leaves and buds in the spring. For example, peach cultivars for northern climates require 700 to 1,000 hours below 45°F and above 32°F before they break their rest period and begin growth. If grown in the southern part of the United States, these peaches will not thrive because this requirement is not met.

Vernalization

Some plants require a chilling treatment to induce flowering. This is especially common in biennials and spring-flowering bulbs.

Plant pests

Plant diseases often grow well at 96°F or higher, increasing the chance of infection. Similarly, insect pests reproduce more rapidly during periods of high temperatures, with resultant high pressure on plants.

Heat units

Plants have a base temperature below which they grow very little. Average temperatures above a threshold "base" temperature (40° to 50°F, depending on plant type) accumulate on a seasonal basis and are called "heat units" (or "degree days") for that season (figure 3). Heat units are useful in estimating time of maturity, predicting the latest feasible date for fall planting, and deciding if long-season fruit cultivars will mature in a specific locality.

To calculate heat units, use the following equation:

$$\left(\frac{\text{High temp for day} + \text{Low temp for day}}{2}\right) - \text{Base temp} = \text{Heat units for that day}$$

Add heat units for each day to those of the previous days to calculate the season's total heat units thus far. A negative number for daily heat units does not decrease seasonal heat units, but rather leaves it unchanged.

Certain sweet corn cultivars mature at 1,500 heat units (degree days). Cool nights like we have in Idaho will slow the accumulation of heat units in comparison with areas of the country that have warm nights. This is why corn labeled "matures in 65 days" can take much longer to mature in a cooler climate!

Low temperatures

Many plants are susceptible to frost and cold temperatures. If temperatures are too cool, there will be a lack of plant growth, a failure of seed germination, and some plants will not set fruit. Species originating in the tropics, for example, are injured by temperatures below 40°F.

Plants have a minimum survival temperature below which they will be severely injured or killed. The amount of plant damage depends on many variables such as the kind of plant, the plant part, the nutrients and moisture in the plant tissues, the season of the year, the temperature during the freeze, the temperature after the freeze, the amount of air movement, and the moisture level in the soil. Other low-temperature considerations in plant growth are discussed below.

Premature flower stalk formation (bolting)

Premature flowering in plants is related to the weather and other environmental conditions. Many biennials will bloom in the first year if cool temperatures follow shortly after planting. Since many biennial plants are grown for their roots, petioles, or leaves rather than for seed, flowering and seed formation make the plant inedible. (Other temperature conditions that will cause plants to bloom early are summer heat and fluctuating temperatures.)

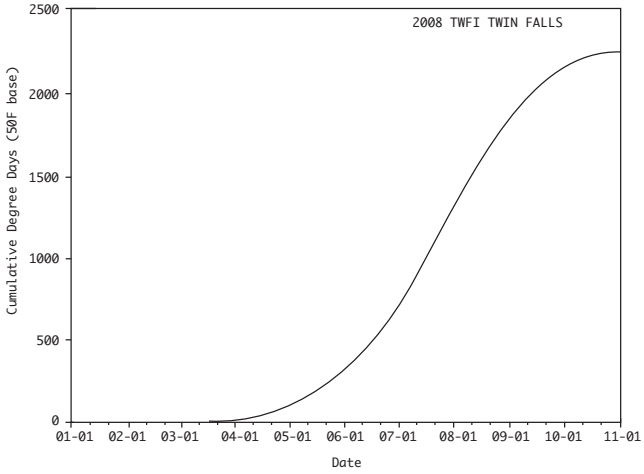


Figure 3. Calculation of accumulated heat units (degree days) in Twin Falls, Idaho, given a base temperature of 50°F (the base temperature for corn). Calculated using the Oregon State University Degree-day Calculator (http:pnwpest.org/cgi-bin/ddmodel.pl)

Development of winter hardiness or dormancy

Perennial plants become more cold tolerant in the fall after they shed their leaves. This is part of the "hardening" process brought on by cooler temperatures and shorter days. Freezing temperatures are necessary for most plants to increase their resistance to cold damage, while sustained freezing temperatures are necessary for maximum cold tolerance.

If temperatures rise for any length of time, plants lose their tolerance to the cold. Cold tolerance will return with colder temperatures, but not if the buds have broken dormancy. Buds will break dormancy during a warm spell if they have already been exposed to chilling temperatures for the period required for bud break. This type of damage is common in northern climates like Idaho's.

Carbohydrate reserves

Plant tissues well supplied with carbohydrates will reach deeper dormancy and be less susceptible to winter cold. Make fertilizer applications and prune well in advance of cool fall temperatures. Plants that are stress free and without new growth will move carbohydrates to the roots and other storage tissues in the fall. Stress from insects, diseases, or other sources will lessen carbohydrate production and storage.

Water status of plant tissue

Winter damage can occur due to a lack of moisture in the plant or plant part. If the plant goes into the winter with little moisture in the root zone, or if dehydration occurs while the soil is frozen, the plant will be injured due to water stress. This is called "physiological drought." This type of damage is particularly detrimental to evergreen trees and will show up as browning needles that dry from the tips down.

The windward and sunny, southwest sides of trees are particularly at risk for browning needles and for bark injury called "sunscald." The windy conditions that are common in many parts of Idaho will intensify injury due to cold temperatures and physiological drought.

To prevent this damage, supply ample moisture during the growing season. However, it is advisable to cut back on moisture in late August and early September in order to allow the plant to enter its dormancy. Water well again in late October or early November after the plant has become completely dormant. Plant roots are still active up until the ground freezes and soil temperatures drop below 40°F.

Frost heaving

Alternate freezing and thawing can force some plants completely out of the soil. This is called "heaving," and young plants without a well-established root system are particularly susceptible to this type of damage, especially when planted in the fall.

Spring frosts

Cold temperatures will freeze tender transplants, emerging seedlings, and opening buds in the spring. Fruit buds are easily frozen once they begin to expand and bloom. Even expanding leaf buds can be frozen when unusually cold spring temperatures occur. On still nights, when temperatures hover near freezing, cold air, which is heavier than warm air, will settle to the bottom of valleys and depressions. These cold spots are called "frost pockets" and may result in cold damage to plants in that area.

Temperature modification

Modifying high temperatures

You can modify high temperatures by shading plants with larger plants or with structures such as a lath houses. Shade cloth suspended over plants will also moderate temperature. Cooler conditions exist on the shady side of a building and under trees. Plants poorly adapted to high temperatures are not good choices in hot, dry areas because extreme measures must be taken to ensure their survival.

Modifying low temperatures

There are many ways to avoid or modify cold temperatures. The most obvious are planting frost-susceptible annual crops after all frost danger is past and selecting perennial plants that are adapted to the cold temperatures in your area. Other methods of modifying cold temperatures include the following:

- **Using covers or heat sinks**. Surround the plants with medium- to large-sized rocks to absorb heat or cover them with fabric row covers, plastic sheeting, or waxed paper cloches in early spring or when frosts are predicted. These techniques reduce outgoing stored solar radiation from soil, rocks, and plants. Depending on the type of cover, you can gain 2° to 6°F of nighttime warmth. Remember that during sunny days it may be 20° to 25°F warmer under the cover, which may require venting to keep plants from becoming too hot.
- **Mulching**. Use a covering of mulch to modify soil temperature. Applied soon after the ground freezes in early winter, mulch will keep the soil frozen and the covered plant crowns at a consistent cold temperature to prevent winter damage. Applied in the spring after the soil warms, mulch moderates soil temperature extremes during the growing season.

  Certain dark or colored mulches can warm the soil early and maintain warmer temperatures when the weather is still cool. To be most effective, an organic mulch layer should be 3 to 4 inches deep. Small stones can be used as mulch to gather heat around plants.
- **Using heaters or fans**. Protecting tree fruits from early spring frosts is done in orchards using heaters or large fans. This equipment stirs the air and prevents an air "inversion," when cooler air is trapped under a layer of warm air.
- **Sprinkling**. When liquid water changes to solid ice, it releases heat. When water is sprinkled on plants as they cool, the heat of freezing will keep the plant surface at or near 32°F. This technique is often used in orchards during bloom time when frost or cold temperatures are predicted.

ROLE OF LIGHT IN HORTICULTURE

Light is the part of the sun's energy visible to the human eye. Solar radiation reaching the earth includes some light near and on either side of the visible light spectrum. Plants use mostly those light rays that can be seen (figure 4).

Light quality

Water vapor in the air acts as a prism to separate light into its various wavelength components. The human eye interprets these wavelengths as color. Beginning with the longest visible wavelength, the rays become shorter through the rainbow color spectrum: red, orange, yellow, green, blue, indigo, and violet. Violet rays are the shortest and are slightly longer than ultraviolet rays, which cause sunburn.

The following rays are used by plants in physiological processes (figure 4):

- **Violet**. These are important for the development of red pigments in plants like apples. At higher elevation, there is less atmosphere to screen out the violet and ultraviolet, resulting in well-colored apples (and maybe sunburn on our skin!). Indigo and violet rays are also responsible for bending flower heads and other plant parts toward the sun (phototropism).
- **Blue-violet and orange-red**. These rays provide the light energy for photosynthesis. In fact, plants appear green to the human eye simply because plant pigments in leaves do not absorb and use green light for photosynthesis; instead, it is reflected back to our eyes.
- **Orange-red and far-red (longer than red)**. This part of the spectrum is absorbed by plants and produces the day length response (photoperiodism).

Supplemental light varies in quality, with fluorescent or cool white bulbs emitting wavelengths in the blue range. Incandescent light is high in the red and orange ranges but also emits the longer heat waves and is too warm to be useful for plant growth. The light bulbs specifically designed for plants are balanced in the wavelengths used by plants.

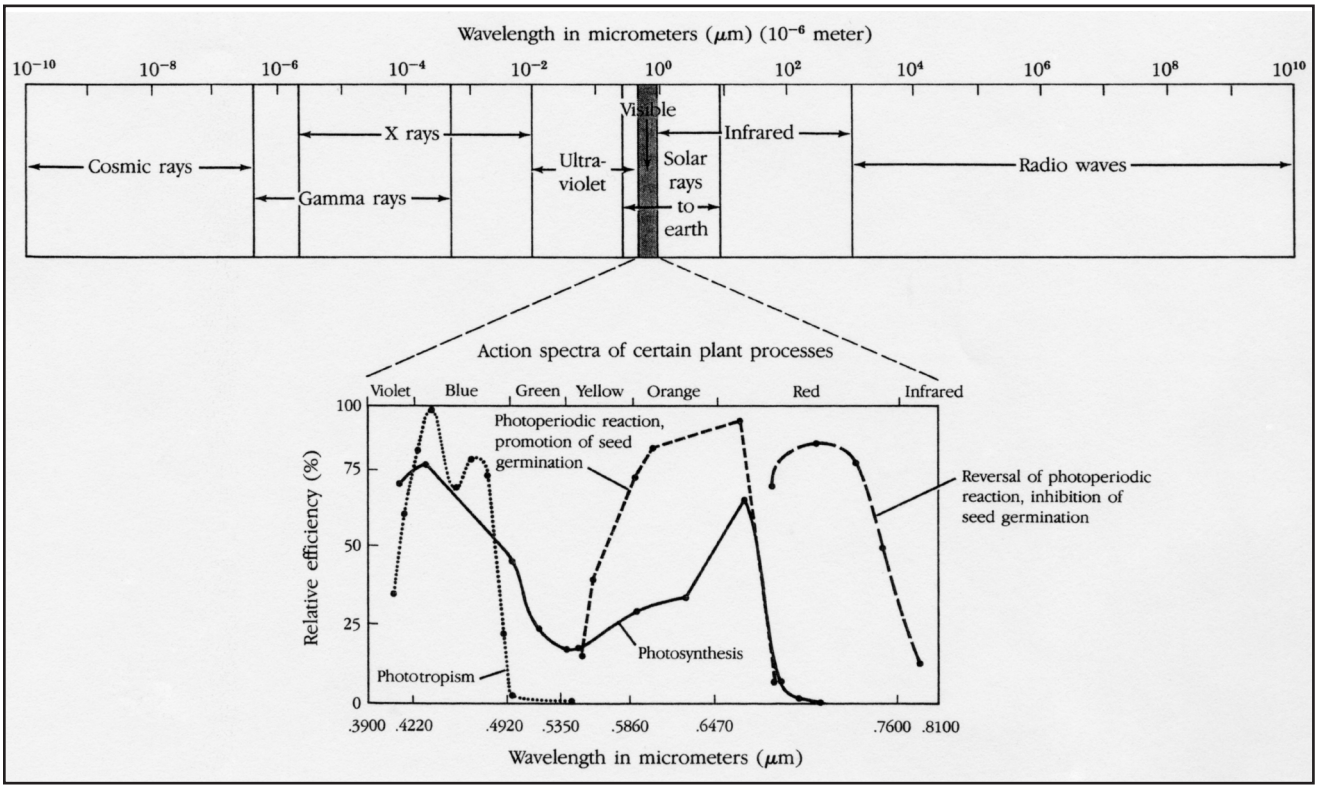


Figure 4. Wavelengths and the responses of plants to the visible rays. (Reprinted from Bienz, D.R. 1980. The why and how of home horticulture. San Francisco: W.H. Freeman and Company.)

Light intensity

Gardeners generally use foot-candles to measure intensity or concentration of light, even though the foot-candle is an older unit based on English measurements (amount of light falling on 1 square foot from a candle burning 1 foot away). You will also hear the term lux to indicate the amount of light that falls on a surface. Lux is a metric unit equal to 1 lumen per square meter. One foot-candle is 10.76 lux. Physicists use a more precise mathematical measure (millimoles per square meter per second). Gardeners use foot-candles because many existing light meters are calibrated in foot-candles.

In full sunlight at noon on a summer day in the desert, light intensity measures about 12,000 to 15,000 foot-candles, possibly as high as 20,000 foot-candles. Light intensity is less in the morning and late afternoon because light from the sun reaches the earth at an oblique angle, filtered through more layers of atmosphere before reaching the surface. For the same reason, light intensity is much lower in winter in the northern hemisphere. On a heavily overcast winter day at noon, light intensity may be as low as 600 to 900 foot-candles in northern latitudes. The interior of a well-lighted home will measure from 50 to 300 foot-candles.

Tropical plants, like many of our houseplants, thrive in nature under a jungle canopy that provides very low light intensity. Plants not from the jungles are able to grow in and use very bright or intense light. Most crop plants use about 1,200 foot-candles of light, but they will grow better in light up to 4,000 foot-candles because of the shading from surrounding leaves. Plants and leaves adapted to low light intensity will sunburn, wither, or die if they are suddenly exposed to higher light intensity. Light intensity can be decreased through shading or increased with supplemental lights, reflective material, or white backgrounds.

Insufficient light will cause plants to stretch and become "gangly" or unusually long. Nodes will be far apart, leaves broad and thin, and the plants will have a loose, open structure. Reduced light intensity can also induce succulence.

Light duration

Plants respond to particular day lengths. Actually, processes that occur during an uninterrupted dark period bring about the plant's response, not processes that occur during the day, but we use day length as the measure. How plants respond to day length is modified somewhat by temperature. Depending on the plant type, blooming, for example, may be delayed or sped up by warm or cool weather. The bloom period can be intentionally altered with specific light treatments or unintentionally altered by lights coming from streetlights or other artificial sources.

Long-day plants

Long-day plants respond to day lengths longer than a certain minimum (usually about 12 hours). Spinach, for example, is a long-day plant and, if planted late in the spring, it will make a flower stalk before producing leaves.

Onion bulbing is a long-day response. Onions produce bulbs during long days, and onion types that do well in northern latitudes require longer days (16 hours) compared with those adapted to more southern locations (11 to 12 hours). Northern-type onions will not produce bulbs in southerly locations because the days never get long enough! Southern types, when grown in the north, produce bulbs before the plant reaches a size adequate to develop a good-sized onion bulb.

Short-day plants

Short-day plants respond to day lengths shorter than a certain maximum (less than about 12 hours). Chrysanthemums are short-day plants and will bloom when day lengths range from 16 hours down to 7 hours depending on the cultivar. They grow and develop plant tissue and carbohydrate reserves during the spring and summer to support fall flowering. Poinsettia is another short-day plant.

Day-neutral plants

Day-neutral plants do not respond to day length, but must have sufficient growth to support flowering. Temperatures must also be acceptable, roughly above 32°F and below 96°F. Geraniums and certain strawberry cultivars are examples of day-neutral plants.

FURTHER READING AND RESOURCES

Books

Benz, D. R. 1980. "Climate, Temperature and Light." Chapter 7 in *The Why and How of Home Horticulture*. San Francisco: W.H. Freeman and Company.

Booklets and Pamphlets

University of Idaho Extension

PNW 221 Cold Resistance of Stone Fruit Flower Buds

PNW 497 Short-Season Vegetable Gardening

Web Sites

National Weather Service, Climate Prediction Center. http://www.cpc.ncep.noaa.gov/index.php

National Oceanic and Atmospheric Administration, U.S. Department of Commerce. http://www.noaa.gov/climate.html

Idaho Climate Summaries, Western Regional Climate Center. http://www.wrcc.dri.edu/summary/climsmid.html

Freeze/Frost Maps, National Climatic Data Center, NOAA Satellite and Information Service. http://www.ncdc.noaa.gov/oa/climate/freezefrost/frostfreemaps.html.

Online Phenology and Degree-day Models, Integrated Plant Protection Center, Oregon State University. http://ippc2.orst.edu/cgi-bin/ddmodel.pl

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Chapter 3

BASIC BOTANY

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Chapter 3
Basic Botany

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INTRODUCTION

Botany is the study of plants. To become a knowledgeable plant person, it is essential to understand basic plant science. It is important to understand how plants grow, how their various parts function, how they are identified and named, and how they interact with their environment. Learning the language of botany means learning many new words. Making the effort to learn this material will prove extremely valuable and will create excitement as you learn to unravel the mysteries of the plant world.

Like all living organisms, plants are complex, and there is far more to know about them than can be learned in an introductory Master Gardener course. Nonetheless, this chapter is designed to provide the Master Gardener student with a brief, but broad, introduction to many aspects of botany.

PLANT NOMENCLATURE AND CLASSIFICATION

Plant classification and the scientific naming of plants are important for correct and precise identification. Plant classification can be useful for Master Gardeners involved in identifying plants, germinating seeds, growing a garden, diagnosing plant problems, or controlling pests.

Plants generally have a common name and a scientific name. Common names are usually simple and easy to remember for the general public. They often are descriptive of the plant; for example, burning bush, bleeding heart, or paper birch.

There are problems, however, with using common names. The same species of plant may have two or more common names, with names varying from country to country, region to region, and sometimes even within a local area. This makes it difficult to communicate about a plant. For example, the state flower of Idaho is *Philadelphus lewisii*, commonly called syringa in Idaho. In other parts of the country, however, the same plant is known as mock orange. To add to the confusion, *Syringa* is the genus for lilac shrubs. Another example of confusing common names is *Malva parviflora*, which is called little mallow, round leaf mallow, cheeseweed, or sometimes buttonweed. The same common name may also be used for several plants. An example is the common name geranium, which can refer to plants in either the genus *Geranium* or the genus *Pelargonium*.

With scientific names, a plant has only one name. Scientific names use the Latin language and often are descriptive of some characteristic of the plant. A dictionary on plant names can help with pronunciation and clarify the meaning of Latin words.

Plants are named using a **binomial** (two-part) naming system. A binomial name includes the plant's genus name (capitalized and italicized) plus the specific epithet name (lowercased and italicized). The name may be followed by the initial of the person credited with originally describing and naming the plant. For example, *Solanum tuberosum* L. indicates that Carl von Linne (Linnaeus), a Swedish physician, described and named the white (Irish) potato.

Plant classification groups plants with similar characteristics, first in a broad sense, then through a series of subgroups, using progressively more specific flower and plant traits. This process continues until a single, unique plant form remains.

This plant is given a binomial species name. Ranked from general to specific, the plant classification groups are as follows: kingdom, division or phylum, class, order, family, genus, species, and variety or cultivar. Each species is assigned to a genus, each genus to a family, and so on. Refer to Table 1 for examples of plant classification.

Understanding plant classification is useful for maintaining a successful garden. For example, vegetable crops should be rotated each year, and rotation can be simplified by grouping plants from the same family. To do so, you need to know which plants belong in which family. A second example: when using the Internet to research solutions to a plant problem, it is absolutely essential to enter the correct scientific name. The more you study plants, the more you likely will appreciate the usefulness of the scientific nomenclature system.

An important distinction among plants at the Division level is between those with seedlings having one seed leaf (**monocots**, such as grasses and lilies) and those with seedlings having two seed leaves (**dicots**, such as beans). Monocot and dicot seeds germinate differently. The distinction between monocots and dicots becomes very important when using herbicides. For example, common lawn herbicides for broadleaf weeds (for example, 2,4-D) will kill only dicot plants, leaving the grass plants (monocots) unharmed.

Family

Master Gardeners usually work with the classification of plants at the family level and below. Plant families are important in gardening because members of the same family often have similar cultural requirements and similar insect and disease problems.

In a family of plants, similarities occur primarily with reproductive parts (flowers, fruit, and seed), although leaves and other plant parts may also be similar. Table 2 includes some common families and some of their characteristics.

Genus

Genus is a subdivision of a plant family. Plants of the same genus share similarities mostly in flower characteristics and genetics. Plants in one genus usually cannot breed with plants in another, but species within a genus will often intercross. The first letter of the genus name is capitalized, and the entire name is italicized or underlined.

Species

Species is a group of individual plants that freely interbreed and have many (or all) characteristics in common. Species names use the binomial naming system of genus and specific epithet.

Variety and cultivar

Variety

Variety is a word commonly used to describe cultivated and hybridized plant types. This is a misnomer; used in its proper context, a variety is a botanical division of a species. It is a subgrouping of plants within a species that differs in some particular way from other members of that species. In the wild, variety may be used to describe a particular regional variant of a species with unique plant size, flower color, or other visible trait. In cultivated plants, variety may be used to designate a particular useful form of a species. For example, cauliflower (*Brassica oleracea* var. *botrytis*) and cabbage (*Brassica oleracea* var. *capitata*) are varieties of the same species. The variety name follows the abbreviation "var." It is written in lower case and is italicized or underlined.

Table 1. Examples of plant classification.

Common name	Black chokecherry	Siskiyou blue Idaho fescue	Western white pine
Kingdom	Planta	Planta	Planta
Division or phylum	Magnoliophyta	Magnoliophyta	Pinophyta
Subdivision	Angiospermae	Angiospermae	Gymnospermae
Class	Magnoliopsida (dicots)	Liliopsida (monocots)	Pinopsida
Order	Rosales	Poales	Pinales
Family	Rosaceae	Poaceae	Pinaceae
Genus	*Prunus*	*Festuca*	*Pinus*
Species	*Prunus virginiana*	*Festuca idahoensis*	*Pinus monticola*
Variety or cultivar	var. *melanocarpa*	'Siskiyou Blue'	

Table 2. Common plant families.

Scientific family name	Common family name	Common plants in family	Family traits
Apiaceae	Carrot family	Carrot (*Daucus carota*) Parsnip (*Pastinaca sativa*) Dill (*Anethum graveolens*) Poison hemlock (*Conium maculatum*)	Flowers usually in simple or compound, flat-topped clusters called umbels; stems often hollow.
Asteraceae or Compositae	Sunflower family	Lettuce (*Lactuca sativa*) Sunflower (*Helianthus annuus*) Zinnia (*Zinnia elegans*) Spotted knapweed (*Centaurea stoebe*)	Flowers organized as heads with ray and disk flowers. One of the largest families: 20,000 species.
Brassicaceae or Cruciferae	Mustard family	Broccoli (*Brassica oleracea* var. *botrytis*) Kale (*Brassica oleracea* var. *acephala*) Cabbage (*Brassica oleracea* var. *capitata*) Radish (*Raphanus sativus*) Shepherd's-purse (*Capsella bursa-pastoris*)	Flowers have four petals that are not joined; there usually are six stamens (four long, two short).
Fabaceae or Leguminosae	Pea or bean family	Common pea (*Pisum sativum*) Common bean (*Phaseolus vulgaris*) Lupine (*Lupinus argenteus*) Hairy vetch (*Vicia villosa*)	Flowers with a distinct upper "flag" petal, arranged in heads or spikes.
Lamiaceae or Labiatae	Mint family	Peppermint (*Mentha* x *piperita*) Sweet basil (*Ocimum basilicum*) English lavender (*Lavendula angustifolia*) Henbit (*Lamium amplexicaule*)	Leaves usually opposite; flowers tubular; stems square.
Poaceae	Grass family	Corn (*Zea mays*) Kentucky bluegrass (*Poa pratensis*) Blue fescue (*Festuca glauca*) Quackgrass (*Elytrigia repens*)	Leaves simple and strap-like; inflorescence usually a long spike. Large family of between 7,500 and 10,000 species.
Ranunculaceae	Buttercup family	Columbine (*Aquilegia vulgaris*) Larkspur (*Delphinium elatum*) Lenten rose (*Helleborus orientalis*) Creeping buttercup (*Ranunculus repens*)	Large and variable family with variable flower form; most species have showy sepals rather than petals.
Rosaceae	Rose family	Apple (*Malus pumila*) Garden strawberry (*Fragaria* x *ananassa*) Rose (*Rosa* spp.) Sulfur cinquefoil (*Potentilla recta*)	Flowers with five (or multiples of five) petals and many stamens
Solanaceae	Nightshade or potato family	Tomato (*Lycopersicon esculentum*) Pepper (*Capsicum annuum* var. *annuum*) Potato (*Solanum tuberosum*) Black henbane (*Hyoscyamus niger*)	Leaves alternate; flowers have five petals fused at the base; stamens attached to the petals and form a column around the pistil.

Cultivar

This word is a contraction of the term "cultivated variety." A cultivar is a very specific, human-bred, cultivated form of a useful crop species. If propagated asexually (vegetatively), cultivars can be termed **clones**. When vegetatively propagated, cultivars maintain their characteristics from generation to generation, thus preserving desirable traits. However, seeds of clones will not produce plants with the same desirable characteristics as the cultivar. If propagated by seeds, cultivars can be termed **lines**.

Cultivar names are indicated by placing the term in single quotation marks or by preceding the cultivar name with the abbreviation cv. (do not use both). The first letter of the cultivar name is capitalized, but the name is not italicized or underlined. An example is the tomato cultivar Early Girl, expressed as *Solanum lycopersicum* 'Early Girl' or cv. Early Girl.

Both ancient practices of plant domestication and modern processes of plant breeding have contributed to the vast pool of plants we have available for food, industry, and beautification. Understanding the titles used to describe these plants will help in making decisions as to which cultivars are suitable for specific uses.

Landrace. This term is used to describe a locally domesticated and utilized form of a plant species that was developed through a long process of selection without the use of modern genetics. Landraces typically have ancient origins, and their production was historically limited to a very small geographical area. They often are specifically adapted to production conditions typical of their point of origin. One example is Palomero Toluqueño, a type of popcorn that was historically grown in the highlands of Mexico.

Landraces typically have improved traits that make them valuable for human use in comparison with the original wild species. At the same time, individual plants within a landrace often vary in appearance, quality, and resistance traits.

Open-pollinated. These cultivars are developed through modern breeding practices, genetically stabilized to ensure uniformity, and then seed propagated using methods that allow uncontrolled distribution of pollen within the crop. They differ from hybrids, which are produced through a process that completely controls pollen transfer. Open-pollinated cultivars will grow true-to-type if seed is collected from parental plants that are isolated from other cultivars of the same species. Most lettuce, bean, and pea varieties for home gardeners are examples of open-pollinated plants.

Heirloom. No universally accepted definition of heirloom exists. Some people consider varieties to be heirlooms only if they are at least 100 years old. Other people feel the proper cut-off date is 1951, the year recognized as the point at which modern hybrid cultivars became available. Nonetheless, there are two fairly common characteristics attributed to heirloom cultivars: (1) they are relatively old, and (2) they are not currently planted in large-scale production agriculture.

Cultivars designated as heirloom have recently become very popular in home garden and small agriculture production. They provide unique appearance and quality characteristics. However, they also tend to be narrowly adapted and lack the pest resistance that is common in modern cultivars.

The terms "open-pollinated" and "heirloom" are often used synonymously. By any standard used to define heirloom, this is incorrect. Open-pollinated refers to any cultivar developed through modern (traditional) breeding methods that is not a controlled-pollination hybrid. Every year, modern breeding programs release new open-pollinated cultivars of many crops and landscape species. Cultivars designated as heirloom, on the other hand, include many of the older, lesser known open-pollinated cultivars, clonal cultivars, and, in some cases, landraces.

Hybrid. Hybrid cultivars are often referred to as F1 hybrids. This means that the seed we purchase and the resulting plants grown are the first-generation offspring of two open-pollinated parents. (The abbreviation F1 stands for the term "first filial" generation.) Hybrid cultivars are limited almost exclusively to food plants, with a few exceptions. In production agriculture, hybrid cultivars can provide many important advantages, including higher yield, greater plant uniformity, more consistent quality, and the combination of the superior traits of two outstanding parents.

The main difference between hybrid and open-pollinated cultivars is that subsequent generations grown from the seed of a hybrid do not breed true to type. Thus, growers cannot collect and use their own seed, but must purchase new seed each year. For this reason, many people do not consider hybrid cultivars sustainable in small-scale agricultural production.

Clonal. Many plant cultivars are not propagated from seed. They are propagated using vegetative parts. Some familiar plants propagated in this manner include potatoes, rhubarb, asparagus, bulb flowers, and most types of fruit trees. Types of plant material used to establish a new generation include tubers, bulbs, root cuttings, stolons or runners, rhizome pieces, and stem cuttings. Many clonally produced cultivars can trace their origins to a single plant discovered many hundreds of years ago.

GMO. Short for "genetically modified organism," GMO cultivars are radically different from the cultivar types discussed previously, all of which have their basis in traditional breeding and/or selection. Biotechnologists have discovered ways to isolate and remove specific genes from one organism and attach them to the chromosomes of a different organism. This makes it possible to give plants traits that nature did not provide.

This technology is widely used in production agriculture to address critical production and nutrition issues. Examples include insect-resistant corn and cotton cultivars (greatly reducing the need for insecticide use), herbicide-resistant soybeans and sugar beets (minimizing the need for expensive hand weeding), and rice cultivars with high levels of vitamin A (reducing the incidence of blindness in many developing countries). Currently, there are no GMO cultivars available for home food production. Many people oppose the use of GMO cultivars, limiting their value for use in small-scale farming or home production of food crops.

PLANT LIFE CYCLES

A plant is classified by its life cycle, specifically how long it lives and how long it takes to complete reproductive processes and develop seed.

Annuals

Annuals grow, mature, flower, produce seed, and die in one season. An annual may be a **summer annual** or a **winter annual**. For summer annuals, the seed germinates in the spring, and a plant develops, matures, and produces seed by the end of the growing season. Summer annuals include zinnias, corn, and beans. Winter annual seed germinates in the fall, producing a plant that overwinters, matures, and produces seed the following growing season. Winter wheat and downy bromegrass (a weed) are winter annuals.

Biennials

Biennials take 2 years or at least part of a second year to complete their life cycle. During the first season, they grow a hardy rosette of basal leaves that will overwinter. During the second season, the plant flowers, produces seeds, and then dies. Parsley and table beets are examples of biennial plants.

Perennials

Perennials live for more than 2 years. **Herbaceous perennials** have soft, nonwoody stems. Herbaceous perennials die back each winter, and a new plant grows from the crown or roots the following spring. Herbaceous perennials may live for 3 to 25 years, or even longer under ideal growing conditions. Many herbaceous plants, such as tomatoes or lantana (a flowering shrub), are perennial in warmer climates, but are grown as annuals in temperate climates.

Woody perennials such as trees or shrubs have a woody stem or trunk. Those that lose their leaves every fall and grow new leaves in the spring are called **deciduous**.

Trees or shrubs that keep their leaves (needles or broad leaves) through the winter are called **evergreens**. Sometimes, the term evergreen may be somewhat of a misnomer because the older needles (those closer to the tree trunk) fall off. For example, a spruce tree will hold its needles for 7 to 10 years, while a pine tree will hold needles for about 3 years.

Woody perennials have a wide range of life spans, ranging from 10 to 12 years for aspens in a home landscape to more than 1,000 years for some conifers. Life expectancy is often linked to growth rates. (Slower growing plants such as bristlecone pines tend to live longer.)

PLANT PARTS AND THEIR FUNCTIONS

Vegetative parts: Leaves, stems, and roots

Understanding plant part terminology (figure 1) and the functions of plant parts will help you identify plants and diagnose plant problems.

Leaves

Leaves are the main structures produced on plant stems. Leaves come in many different shapes, sizes, and arrangements and are used for plant identification. They also serve many vital roles, the most important being the harvest of light energy. The leaf is the primary site of photosynthesis, respiration, and transpiration, all important growth processes for plants.

Leaf parts and structure. There are two main parts to a leaf: the **blade** (flat, thin portion) and the **petiole**. The petiole attaches the blade to the stem and contains conducting tissues between the leaf and the stem.

The outer cell layers on the top and bottom of the leaf blade are the **epidermis**; they serve to protect the inner leaf tissue. Specialized epidermal cells on the undersides, and sometimes upper sides, of leaves form openings called **stomata**. (The singular of stomata is **stomate**.) Open stomata keep water and nutrients moving through the plant and allow the exchange of carbon dioxide and oxygen between the air inside and outside the leaf, a process that is critical for photosynthesis. Conditions that cause plants to lose a lot of water (high temperature, wind, low humidity) cause the stomata to close. Consequently, it is important to keep plants adequately watered to allow air exchange for photosynthesis.

Some plant leaves have a waxy layer on the epidermis called the **cuticle**. The cuticle protects the leaf from dehydration and prevents penetration of some disease-causing organisms.

The leaf blade texture (smooth, hairy, waxy, etc.) is often important to consider when applying pesticides. For example, herbicides may not make good contact on hairy or waxy leaves; consequently they are less effective. Also, some pesticides may remove a desired waxy leaf texture. When this happens on Colorado spruce needles, for example, the color of the needles may change from blue to green.

Leaf arrangement and shape. Leaves are attached to a stem in one of three patterns: **opposite**, **alternate**, and **whorled**. Opposite arrangement means two leaves attach at the same point, but on opposite sides of the stem. With alternate arrangement, leaves are attached at alternating points from one side of the stem to the other. In a whorled arrangement, three or more leaves are attached at the same point. Leaf arrangement is often used for plant identification. For example, maple trees have opposite leaf arrangement, and birch and willow trees have alternate leaf arrangement.

Leaves are most often thought of as being flat blades of various shapes. Examples include the leaves of maple trees or green beans. However, a leaf blade may be needle-like, such as in conifers. Spruce trees have about 1-inch-long needles, and pine trees 2- to 3-inch-long needles. Leaves can also be scale-like, such as in redcedar and arborvitae, or flat and strap-shaped as in grass plants. Leaf shapes are also helpful for identification.

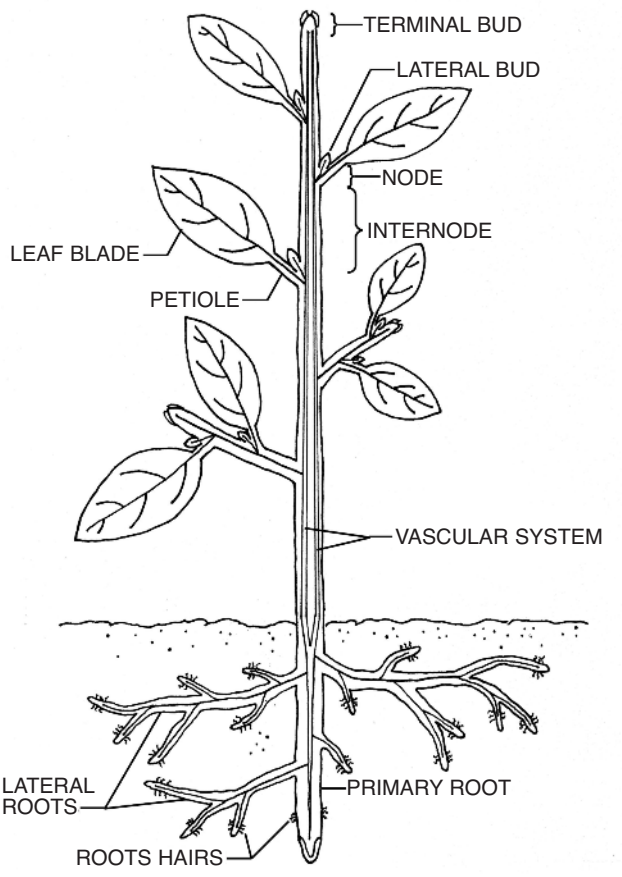


Figure 1. Parts of a vascular plant.

Photosynthesis in leaves. Plants are able to take solar energy and turn it into chemical energy through the process of photosynthesis. Without photosynthesis, life on earth would not exist. All other life forms depend on the oxygen and food that photosynthesis provides.

Inputs for photosynthesis include carbon dioxide, water, and light. Carbon dioxide enters the leaf through the stomata, water enters through the roots, and light energy comes from natural or artificial light. Outputs of photosynthesis are oxygen and carbohydrates.

Gardeners are basically managing a living plant factory. The goal is to maintain plant health and manage the environment so plants can produce the most carbohydrates possible. Anything that damages the leaves (diseases or insect feeding) or reduces their ability to absorb sunlight (too much shade) or take in carbon dioxide will limit the photosynthetic capability of a plant.

Respiration in leaves. Respiration is essentially the reverse of photosynthesis. It is the process by which carbohydrates are converted into energy. With the production of energy, sugars and oxygen are converted to carbon dioxide, water, and a small amount of heat. Respiration releases energy to build new tissues, maintain chemical processes, and produce growth within the plant. Respiration occurs in all cells at night as well as during the day, a key point that is discussed below.

Relationship between photosynthesis and respiration. The rates of photosynthesis and respiration depend on temperature. Plants have an optimum temperature range and a maximum temperature for photosynthesis. The rate of photosynthesis will increase with increasing temperature up to a certain point and then decrease at higher temperatures. Likewise, higher temperatures will increase respiration. Unlike photosynthesis, however, respiration continues to rise with increasing temperature.

Photosynthesis does not occur at night, but respiration does. If nighttime temperatures are too warm, the plant will use all of the energy produced by photosynthesis during the day for metabolic processes at night just to stay alive, rather than converting the carbohydrates into new plant cells. This can affect the portions that we eat, such as potato tubers and cucumbers. If days are hot and nights are warm, plant growth will be reduced and yields may decrease. Grasping this relationship between photosynthesis and respiration will help you understand plant growth and yield variability from year to year.

Transpiration in leaves. The loss of water through leaf stomata is called **transpiration**. Transpiration pulls water containing dissolved nutrients from the soil through the roots and the rest of the plant. It also provides evaporative cooling for leaf tissue. About 90 percent of the water entering roots is used in transpiration, and the remainder is used for photosynthesis.

The amount of water used depends on temperature. As temperatures rise, the amount of water needed increases. Consequently, it is critical to irrigate more frequently during warm weather. Also, plants growing in a dry climate need more water than those growing in a more humid environment.

Stems

The stem is the main above-ground support structure of a plant. It contains the vascular system that allows water, nutrients, and carbohydrates to move within a plant.

Parts of a stem. All stems have **nodes**, where leaf attachments occur. Nodes contain buds that may develop into leaves, flowers, or lateral branches. The areas between nodes are called **internodes**. Plants that grow in reduced light conditions may have very long internodes.

It is important to be able to recognize nodes when pruning. For example, it is often necessary to remove a tree branch back to a node that will produce a new stem. Also, when plants are propagated asexually via vegetative cuttings, new roots most often form at nodes.

Types of stems. Most stems grow above ground, and many grow erect (for example, trees, corn, and sunflowers). Some above-ground stems can also grow along the ground, such as cucumbers and pumpkins. There are also several other types of stems that gardeners need to understand because plants with these modified stems may need to be managed differently.

Crowns are compressed above-ground stems with very short internodes. Examples of plants with crowns include dandelions, strawberries, rhubarb, asparagus, and many grasses such as Kentucky bluegrass. Rhubarb and asparagus are propagated by planting crowns. Crown identification is especially important when planting strawberries, as covering the crown with soil is detrimental to their growth.

Spurs are short, stubby stems commonly found on fruit trees such as apple and pear. Spurs produce fruiting buds. If a severe pruning cut is made close to a spur, the spur may produce a stem rather than the intended fruit.

Stolons, also called runners, are horizontal stems, either fleshy or semiwoody, that grow on top of the soil surface. For example, stolons attach a strawberry plant to its plantlets. Some types of grass, such as creeping bentgrass, form stolons. This species often is planted on golf course putting greens.

Rhizomes are stems that grow below ground. A very popular lawn grass, Kentucky bluegrass, spreads by rhizomes. Another grass that spreads by rhizomes is quackgrass, which is considered a difficult-to-control weed.

There are several other types of modified stems, such as tubers (the edible part of potatoes) and bulbs (tulips and onions). These topics are covered in more detail in the chapter titled "Herbaceous Ornamentals."

Vascular system

Plants need a system to transport water and nutrients from the roots to the leaves and to move photosynthetic sugars to stems, roots, and other plant parts. You could think of this vascular system as being similar to the vessels and veins in vertebrate animals. There are two types of vessels in plants. **Xylem vessels** conduct water and minerals up from the roots, while **phloem tubes** carry sugars and other compounds from the leaves to the rest of the plant.

The xylem and phloem are grouped in vascular bundles. In dicots, the vascular bundles are arranged in a continuous ring in the outer perimeter of the stem. In woody plants (trees and shrubs), these vascular bundles are located just under the bark. Thus, they can be easily damaged by lawn mowers, string trimmers, or stems rubbing against each other. In monocots, the vascular bundles are scattered throughout the stem and are not as easily damaged.

Buds

A **bud** is a fully formed but undeveloped shoot or flower. If a bud is at the tip of a shoot, it is called a **terminal bud**. Regardless of location, buds that form shoots or leaves are **vegetative buds**. **Flower buds** produce one or more flowers. Mixed buds produce both shoots and flowers.

Buds may grow immediately after they are formed, or stop growing and remain **dormant** until the following spring. Buds on many plants, such as fruit trees, require a specified duration of cold temperature below a critical level before they will grow in the spring. This cold period is easily accomplished in Idaho, but may not be achieved in warmer states such as Florida or California.

During dormancy, buds can tolerate very low temperatures without damage. However, once the plant has had enough cold temperature to satisfy the requirement for growth, a new bud can easily be damaged by subsequent cold temperatures.

Roots

Roots are often neglected or forgotten while caring for plants because they are not visible. However, roots are a critical plant part that gardeners need to understand to properly care for plants. Roots make up a large proportion of the total plant—about 20 to 30 percent of the total volume. Small feeder roots are so numerous that the total amount of roots can account for up to 90 percent of the surface area of a plant!

Establishing a healthy root system is one key to growing attractive and productive plants. The importance of roots is evident when transplanting trees. Transplanted trees often suffer from "transplant shock" and do not seem to grow well the first 2 or 3 years. The problem is the amount of root system that was removed during the transplanting process. Bare-root or balled and burlapped trees have less than about 5 percent of their original root system and cannot grow normally until a complete new root system has developed.

Root functions. Roots absorb nutrients and moisture from the soil or growth medium (potting soil), anchor the plant, physically support the stem, and move water and minerals to the stem. In some cases, roots serve as food storage organs. Roots

profoundly affect the size and vigor of the plant, the method of propagation, adaptation to soil types, and responses to cultural practices and irrigation.

Types of root systems. After the primary root emerges from the seed, it may continue to grow straight down and become a **taproot**, or it may branch and form a **fibrous** root system with many side (lateral) roots.

Root growth. There is a common misconception that tree roots penetrate the soil to several feet. In fact, most of the functional feeder roots of woody plants—those that absorb water and nutrients—are located in the upper 18 inches of soil. Many plants have even more shallow root systems. The depth to which roots penetrate depends on the plant type, soil texture and structure, and water status. A dense, compacted soil layer or a high water table will restrict or terminate root growth.

Another misunderstanding about roots is that they will grow to "find" water. Roots will not grow into dry soil, so unless soil is moist, roots will not grow to their maximum length.

The roots of most plants are far more extensive than the above-ground area beneath the plant. Tree roots extend several feet beyond the drip-line of the tree. Disturbing the soil by, for example, digging a trench or compacting the soil via vehicular or foot traffic will have an adverse effect on the tree's health.

Reproductive parts: Flowers, fruits, and seeds

Flowers

Flowers are the sexual reproductive organs of seed-bearing plants, designed to produce and distribute pollen, accept pollen, provide a way to fertilize the ovary, and nourish and protect the developing seed (Figure 2). This makes flowers critical to the survival, adaptation, evolution, and distribution of plant species.

Angiosperms produce the reproductive structures we recognize as flowers and are the group of plants discussed in this section. **Gymnosperms** (conifers) produce pollen and seeds, but don't have structures recognizable as flowers. Some plants, such as ferns, do not produce flowers or seeds and instead reproduce using spores.

Parts of the flower. A typical flower has four major parts: **sepals**, **petals**, **stamens**, and **pistils**. However, not all flowers have all four parts. Flowers lacking one or more of these basic parts are called **incomplete** flowers. In nature, any combination of flower parts can occur. The shape and visibility of flower parts also vary widely among plant species.

Sepals are the outer covering of the flower when it is in the bud stage. They are usually green and leaf-like in appearance. In some plants, they have

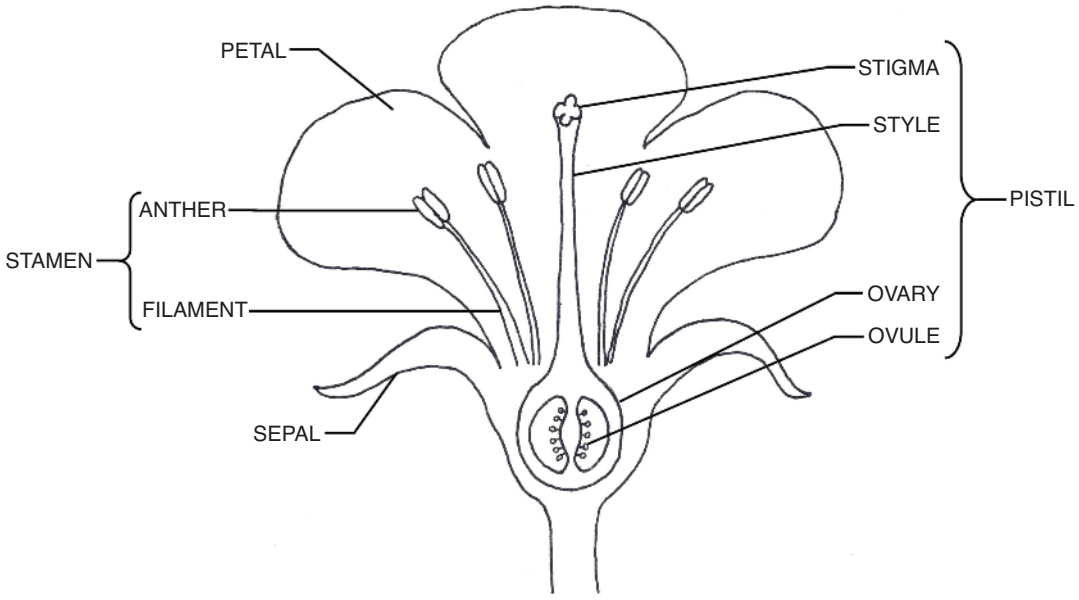


Figure 2. Parts of a flower.

the form and color of petals (for example, in tulips). Collectively, all of the sepals form the **calyx**.

Petals are usually the largest and most visible feature of a flower and are commonly brightly colored. The color helps attract insects to pollinate the flower. As a group, the petals form the **corolla**.

Stamens are the male parts of the flower and are usually found near the center of the flower. Each flower contains multiple stamens—in some cases very large numbers. At the top of each stamen is an anther sac in which pollen is produced.

The **pistil** is the female component of the flower. The upper part of the pistil, called the **stigma**, usually has some type of sticky surface designed to trap and accept pollen. The base of the pistil contains one or more **ovules** (eggs) that develop into seeds after pollination and fertilization.

Arrangement of male and female flowers. Many species of plants produce flowers lacking one or more of the sexual parts and are referred to as **imperfect**. Flowers with no pistils are male flowers (**staminate**). Flowers with no stamens are female flowers (**pistillate**).

Depending on species, imperfect flowers may be arranged within and among plants in a number of ways. Individual plants may produce separate male and female flowers on the same plant. The term for this arrangement is **monoecious** (a Latin term meaning "one house"). Cucumbers are an example of this type of plant; the male flowers (the ones lacking tiny fruit under the corolla) and female flowers (the ones with a tiny cucumber under the corolla) alternate along the vines (see Table 3 for additional examples of common monoecious species).

Other species may have separate male and female plants, with flowers of only one sex on any single plant. The term for this arrangement is **dioecious** (a Latin term meaning "two houses"). Holly is an example of a dioecious plant. Only the female plants produce berries, and only if a male plant is nearby to supply pollen (see Table 3 for additional examples of dioecious plants).

Pollination of flowers. For seed to develop, pollen must be transferred from the anthers to the pistil, where it can fertilize the ovules. Some plants require a pollinator to transfer pollen from flower to flower. Pollinators can include many types of animals, most commonly insects or birds. Honeybees are an example of common pollinating insects.

Plants that require a pollinator (such as an apple tree) produce sticky pollen that adheres to animal visitors. Other plants, such as corn, utilize the wind for pollination. They release large amounts of small, light, nonsticky pollen grains into the air and rely on chance to carry them to the pistil of a nearby plant. As a rule, plants that require pollinators have large and/or showy flowers. Wind-pollinated plants tend to have inconspicuous flowers.

Table 3. Examples of plants with monoecious or dioecious flower arrangement.

	Scientific name	Common name
Monoecious species	*Betula alba*	European white birch
	Curcurbita pepo	Pumpkin
	Juglans nigra	Black walnut
	Musa acuminata	Banana
	Quercus macrocarpa	Bur oak
	Salix matsudana	Globe willow
	Zea mays	Corn
Dioecious species	*Acer negundo*	Box elder
	Asparagus officinalis	Asparagus
	Fraxinus pennsylvanica	Green ash
	Juniperus horizontalis	Carpet juniper
	Populus alba	White poplar
	Spinacia oleracea	Spinach
	Taxus cuspidate	Japanese yew

Fruits

After pollination, the embryo starts to develop, fruit forms, and seeds enlarge within the fruit. Fruits come in many sizes and forms. They may be fleshy (peach) or dry (elm). They can be single (avocado) or aggregated (raspberry; the crumbles of a raspberry are actually individual fruits). They can have a hard coat (a nut) or soft, fragile skin (tomato). They can hold one seed (plum) or many (cantaloupe).

The fruit serves to protect the developing seed. Once the seed is mature, the fruit can be important in seed dissemination. Sweet, edible fruits, such as serviceberries, are often consumed by animals, and the seed is then deposited elsewhere in their droppings. Other types of fruit may dry and break open violently (dehiscence), flinging the seed some distance from the mother plant. An example of a plant using this dissemination mechanism is chickpea. Still other fruits may have "wings" (**samaras** in maples) or "umbrellas" (the parachute-like **pappus** of dandelions) that allow them to "ride the wind" to a new location. Cockleburs have a barbed fruit that attaches itself to clothing or animal fur, providing the seed with transportation. Small animals gather, transport, and bury nuts, not only moving the seeds but planting them as well.

Fruits are also important for human nutrition, and many garden plants are produced for their edible fruits. Some fruits, such as cucumbers and peas, are picked and eaten at a botanically immature stage. Others reach full maturity before being picked, meaning growth is complete and the seed is capable of germination. Examples are apples and pumpkins.

Seeds

Seeds form when ovules are fertilized after pollination. Thus, they contain genes from both the female and male parents. Each seed is an encapsulated embryo, in essence a miniature but fully formed plant within a protective coat. Once the embryo is formed, it usually goes into a state of arrested development until the seed is separated from the mother plant and is exposed to proper growing conditions.

Seeds, in addition to fruits, are important sources of food for humans. We grow many plants for their edible seeds, including nuts, legumes, and grain.

Seed viability. In order for seeds to grow, the embryo must be **viable**, or alive. Factors such as improper pollination, less-than-ideal growing conditions during seed development, or competition within a plant for resources can lead to **nonviable** seed. Nonviable seeds may look normal, but will not grow, even when planted in optimal conditions. In nature, nonviable seeds affect the ability of plants to propagate themselves. In the garden, nonviable seeds have a negative impact on plant stands and productivity. Nonviable seeds should not be confused with dormant seeds, which are discussed below.

Seeds enable plants to bridge periods of time when growing conditions are not favorable (winter, dry periods, etc.). Consequently, if conditions are appropriate, seeds of most plant species can remain viable for extended periods of time. Germination and growth may be delayed until suitable growing conditions occur. Having seeds of desirable plants remain viable for many years is beneficial, but when weed seeds remain viable for many years, it creates a need for ongoing weed management.

There are exceptions to the rule of extended seed viability. The seeds of some plant species are capable of growth for only a few days and then only if kept constantly moist. Species of plants with short periods of viability usually live in warm, or at least moist, conditions and often produce seeds that develop within wet, pulpy fruits.

Recently purchased seed has usually gone through a certification process, meaning the germination percentage has been tested in a laboratory and acceptable levels of seed viability ensured. Older seed or seed that has not been certified can be tested at home to make sure it is viable. Before testing germination, make sure the seed is not dormant (see a discussion of dormancy below).

A quick, simple way to test viability of most seeds is to float the seed in a container of water. Seeds that float are usually not viable; live seeds will sink. However, the most reliable method for assessing viability is a germination test. Place a known quantity of seeds on a moist paper towel and seal it in a plastic bag. After a week to 10 days, inspect the seed to determine the percentage that has sprouted.

Seed storage. Due to the tendency of seed to remain viable over extended periods of time, seed can often be stored for 1 to several years, depending

on species and storage conditions (Table 4). Even under ideal conditions, however, seeds of some plants (such as onions, leeks, and parsnips) may remain viable for only 1 year. Seeds of other plant species (such as radishes, tomatoes, grains, and many grass species) may remain viable at least 6 and sometimes more than 20 years.

Successful seed storage requires proper conditions. The keys to long storage are temperature and humidity, with cool, dry conditions being best. The "rule of 90" can help you determine a suitable storage site. Measure the temperature and relative humidity of the intended storage location and add the two values together. If the sum is less than 90, extended seed storage should be successful. Low humidity is the most critical factor for seed storage, but generally, lowering either humidity or temperature will extend the storage period. Long-term viability of seeds can be ensured by placing the seed in a sealed container with a desiccation gel packet and placing the container in a freezer.

Seed dormancy. Some seeds, although viable and planted under correct conditions, fail to grow. These seeds are exhibiting a natural survival characteristic termed **dormancy**. Dormancy is an adaptation of some plants to keep seeds from germinating until conditions favor seedling survival. Most of our common food crops and annual flowers lack dormancy, meaning the seed will grow as soon as it is planted into warm, moist soil. However, many perennial flower species (such as monkshood, alliums, columbines, and penstemons) and most hardy shrubs and trees produce seed with some form of dormancy. In these cases, dormancy must be broken before seedling establishment can be successful.

The most common mechanisms of dormancy are **seed coat impermeability** and **embryo dormancy**. Seed coat dormancy is caused by the presence of a thick, hard seed coat that is impermeable to water. In nature, weathering, soil abrasion, the action of microorganisms or passage through the digestive tract of an animal can soften the seed covering, thus allowing the seed to take up water and begin growing.

For garden production, an artificial method known as **scarification** can be used to break or soften the seed coat. The simplest scarification method is mechanical; simply scratch the seed coat with sandpaper or nick it with a knife. Heat treatments using boiling water can also disrupt the seed coat enough to allow germination. With this method, it is important to use caution to avoid personal injury. Also, be sure you know the proper length of treatment to avoid damaging or killing the seed.

Embryo dormancy is a chemical/physiological condition that prevents growth, usually associated with the balance of growth hormones in the seed. In nature, this type of dormancy ensures that seedlings will emerge in the spring, rather than in the fall. The hormonal balance of the seed changes toward a status favoring growth during exposure to cold, moist soil conditions. This type of dormancy can be overcome by **stratification**, a process of artificially chilling seeds under moist conditions. Place the seed in moist potting soil in a small plastic bag and place the bag in a refrigerator for 1 to 3 months.

Seed dormancy attributes and the methods required to overcome dormancy vary widely among plant species. Success with many plants depends on understanding dormancy characteristics and finding the best ways to satisfy dormancy requirements. Good reference materials are available to determine necessary conditions for germinating seed of difficult species.

Table 4. Examples of longevity and minimum germination (percentage of live seed required to ensure successful production).

Kind of seed	Longevity (years)	Minimum germination (percent)
Bean	3	70
Beet	4	65
Carrot	3	55
Corn, sweet	2	75
Cucumber	5	80
Lettuce	1	80
Muskmelon	5	75
Pea	3	80
Pumpkin	4	75
Radish	4	75
Spinach	3	60
Squash	4	75
Watermelon	4	70

*Source: http://www.ext.colostate.edu/Pubs/Garden/07221.html

PLANT DEVELOPMENT

Plants go through definable stages of life, beginning with germination (sprouting) and ending with senescence and death. Some annuals complete this entire process within a few months, while some tree species live for thousands of years.

Seed germination

Plant development begins with the germination of a seed. First, the seed swells as it absorbs water. The first root (**radicle**) emerges from the seed coat and grows downward. In proper soil moisture conditions, the new roots and root hairs grow down into the soil to anchor the plant and acquire water and minerals. Meanwhile, the shoot portion of the stem emerges from the seed and begins extending toward the soil surface.

During germination and seedling establishment, young plants are vulnerable to damage from conditions that may not damage an established plant. Lack of moisture, excessive heat or cold, pests, and diseases can all kill or seriously damage an emerging seedling. For example, an established plant may be hardy to -25°F, while a tender young plant of the same species may be hardy to only 32°F. As the fragile new shoot moves up through the soil, it may also be damaged by the inability to penetrate heavy or compacted soil.

Because of this extreme vulnerability, germinating seedlings require that we pay careful attention to cultural details. We must adequately prepare the soil, plant seed to the proper depth, maintain proper moisture conditions, minimize exposure to pests, and control temperature as much as possible.

Vegetative growth stage

Once a seedling is established, the size and complexity of the plant increases as the first true leaves are formed. Stems elongate and produce additional leaves. The leaf surface increases, thereby enhancing the plant's ability to capture and utilize light. During this stage of development, growth is rapid and plant parts tend to be large and succulent. Also, the growing plant begins to display characteristic branching and rooting patterns. For example, carrots will produce fern-like leaves and a long taproot, while blue fescue will develop long, narrow leaves from a crown and a dense, fibrous root system.

New growth on all plants develops from localized **meristems**—specific regions of rapidly dividing cells. Meristematic tissues within any plant include those providing both **apical** and **lateral** growth. The apical meristems are found at the tips of stems and roots and produce cells resulting in longer stems and branches. Lateral meristems are located along the interior of the stem and roots and serve to increase the diameter of stems, trunks, branches, and roots. Lateral meristems are especially important in the expansion (increase in diameter) of woody tissues in trees and shrubs.

Grass plants have a unique form of apical meristem called the **intercalary meristem**, located at the base of the leaves. Intercalary meristem cells divide and produce new growth from the leaf base, giving grasses the unique ability to regrow after mowing or grazing. Scalping grass with a mower (cutting to a very short length) or overgrazing may damage or remove this meristem and cause a bald spot (no grass) in the lawn or pasture.

Reproductive growth stage

Upon achieving adequate size and storing sufficient energy, flowering plants go through a process of physiological change that favors the development of reproductive organs at the expense of vegetative growth. Among angiosperms, this means producing flowers and fruits. Once flowering is induced, particularly with annuals and herbaceous perennials, leaf growth usually slows and the plants become more fibrous and stout. For annuals, the reproductive process occurs only once before the plant senesces and dies. For long-lived perennial and woody species, the reproductive cycle may be repeated many times during the life span of a single plant.

Flowering is influenced by many external and internal factors, including genetics, plant mass, plant health, hormone balance, temperature, and day length. Cold or warm temperatures at a specific stage of growth can trigger the flowering process. For example, consistent cold weather will cause young broccoli plants to bloom early instead of growing large heads. Another important trigger for some plants is the length of the light period. Onions, for example, require increasingly long early summer days to trigger bulb growth. These triggering mechanisms ensure that the plants produce flowers

during the optimal time of the year so that flowering and fruit development can be unhindered.

During fruit set—the next phase of reproductive growth—the ovary develops into a fruit with seed. Fruit and seed development takes a great deal of energy. For this reason, it may be beneficial to prevent fruit from developing when plants are just getting established. Dead-heading is another example of preventing fruit development, in this case to promote more flowering. Any stress that reduces photosynthesis—drought, nutrient deficiencies, insects, or diseases—will negatively affect fruit development.

Senescence

For annuals and biennials, death is the next and final stage following fruit development. **Senescence** is a series of steps that lead to the death of a plant. The plant ceases to metabolize, and nutrients are moved from the vegetative structures to the fruits.

Perennial plants do not die after fruit production. On herbaceous perennials, however, fruiting may signal an annual dieback of foliage. In woody species, fruiting may or may not be associated with fall leaf drop and annual dormancy.

For all plants, the stages of development associated with maturation and senescence are accompanied by a lack of response to outside influences. In other words, the plants are programmed to naturally decline, and no inputs of nutrients, moisture, or any form of tender loving care will extend their life. During this stage of development, plants also become more prone to diseases and insect feeding. Luckily, pests do little lasting damage to plants at this stage of their lives, and efforts to control pest issues during senescence are usually unwarranted.

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Chapter 4

PLANT PROPAGATION

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Chapter 4
Plant Propagation

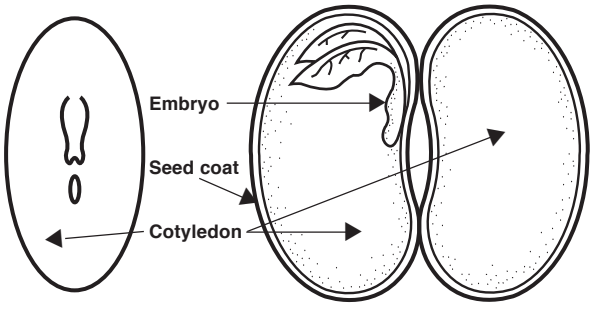
Susan M. Bell, Extension Educator, Ada County

I. Sexual Propagation

Sexual propagation involves the union of the pollen (male) with the egg (female) to produce a seed. The seed is made up of three parts: the outer seed coat, which protects the seed; the endosperm (cotyledon), which is a food reserve; and the embryo, which is the young plant itself. When a seed is mature and put in a favorable environment, it will germinate, or begin active growth. In the following section, seed germination and transplanting of seeds will be discussed.

A. Seed

To obtain quality plants, start with good quality seed from a reliable dealer. Select varieties to provide the size, color, and habit of growth desired. Choose varieties adapted to your area that will reach maturity before an early frost. Many new vegetable and flower varieties are hybrids, which cost a little more than open pollinated types. However, hybrid plants usually have more vigor, more uniformity, and better production than nonhybrids and sometimes have specific disease resistance or other unique cultural characteristics. Disadvantages of hybrids: seed cannot be saved as they do not breed true, and they may have a higher fertility requirement.



Bean seed with interior parts indicated

Although some seeds will keep for several years if stored properly, it is advisable to purchase only enough seed for the current year's use. Good seed will not contain seed of any other crop, weed seeds, or other debris. The seed packet usually indicates essential information about the variety, the year for which the seeds were packaged, germination percentage you may typically expect, and notes of any chemical seed treatment. If seeds are obtained well in advance of the actual sowing date or are stored surplus seeds, keep them in a cool, dry place. Do not freeze seed. Laminated foil packets help ensure dry storage. Paper packets are best kept in tightly-closed containers and maintained near 40°F in low humidity.

Some gardeners save seed from their own gardens, however, such seed is the result of random pollination by insects or other natural agents and may or may not produce plants typical of the parents. Open pollinated varieties are best for seed saving. Vegetable seeds are discussed in Chapter 19.

B. Germination

Four environmental factors affect germination: water, light, oxygen, and heat.

1. Water—The first step in the germination process is absorption of water. Even though seeds have great absorbing power due to the nature of the seed coat, the amount of available water in the germination medium affects the uptake of water. An adequate, continuous supply of water is important to ensure germination. Once the germination process begins, a dry period will cause the death of the embryo.
2. Light—Light is known to stimulate or to inhibit germination of some seed. The

light reaction involved here is a complex process. Some crops that have a requirement for light to assist seed germination are ageratum, begonia, browallia, impatiens, lettuce, and petunia. Conversely, centaurea, annual phlox, verbena, and vinca will germinate best in the dark (Table 1). Many other plant seeds are not specific in their light or dark requirements.

Seed catalogs and seed packets often list germination or cultural tips for individual varieties. When sowing light-requiring seed, do as nature does and leave them on the soil surface. If they are covered at all, cover them lightly with fine peat moss or fine vermiculite. These two materials, if not applied too heavily, will permit some light to reach the seed and will not limit germination. When starting seed in the home, supplemental light can be provided by fluorescent fixtures suspended 6 to 12 inches above the seeds for 16 hours a day.

Table 1. Seed requirements.

Plant	Approximate time to seed before last spring frost	Approximate germination time (days)	Optimum germination temperature (°F)	Germination in light (L) or dark (D)
Begonia	12 weeks	10 to 15	70	L
Browallia	or more	15 to 20	70	L
Geranium		10 to 20	70	D
Larkspur		5 to 10	55	D
Pansy (Viola)		5 to 10	65	D
Vinca		10 to 15	70	D
Dianthus	10 weeks	5 to 10	70	—
Impatiens		15 to 20	70	L
Petunia		5 to 10	70	L
Portulaca		5 to 10	70	D
Snapdragon		5 to 10	65	L
Stock		10 to 15	70	—
Verbena		15 to 20	65	D
Ageratum	8 weeks	5 to 10	70	L
Alyssum		5 to 10	70	—
Broccoli		5 to 10	70	—
Cabbage		5 to 10	70	—
Cauliflower		5 to 10	70	—
Celosia		5 to 10	70	—
Coleus		5 to 10	65	L
Dahlia		5 to 10	70	—
Eggplant		5 to 10	70	—
Head lettuce		5 to 10	70	L
Nicotiana		10 to 15	70	L
Pepper		5 to 10	80	—
Phlox		5 to 10	65	D
Aster	6 weeks	5 to 10	70	—
Balsam		5 to 10	70	—
Centaurea		5 to 10	65	D
Marigold		5 to 10	70	—
Tomato		5 to 10	80	—
Zinnia		5 to 10	70	—
Cucumber	4 weeks	5 to 10	85	—
Cosmos	or less	5 to 10	70	—
Muskmelon		5 to 10	85	—
Squash		5 to 10	85	—
Watermelon		5 to 10	85	—

(—) means no specific light or dark requirements.

3. Oxygen—In all viable seed, respiration takes place. The respiration in dormant seed is low, but some oxygen is required. The respiration rate increases during germination, therefore, the medium in which the seeds are placed should be loose and well aerated. If the oxygen supply during germination is limited or reduced, germination can be severely retarded or inhibited.
4. Heat—A favorable temperature is another important requirement of germination (Table 1). It not only affects the germination percentage but also the rate of germination. Some seeds will germinate over a wide range of temperature, whereas others require a narrow range. Many seed have minimum, maximum, and optimum temperatures at which they germinate. For example, tomato seed has a minimum germination temperature of 50°F and a maximum temperature of 95°F, but an optimum germination temperature of about 80°F. Where germination temperatures are listed, they are usually the optimum temperatures unless otherwise specified. Generally, 65° to

75°F is best for most plants. This often means the germination flats may have to be placed on radiators, heating cables, or heating mats to maintain optimum temperature. The importance of maintaining proper soil temperature to achieve maximum germination percentages cannot be over-emphasized.

Germination will begin when certain internal requirements have been met. A seed must have a mature embryo, contain a large enough endosperm to sustain the embryo during germination, and contain sufficient hormones or auxins to initiate the process.

C. Methods of Breaking Dormancy

One of the functions of dormancy is to prevent a seed from germinating before it is surrounded by a favorable environment. In some trees and shrubs, seed dormancy is difficult to break, even when the environment is ideal. Various treatments are performed on the seed to break dormancy and begin germination.

1. Seed scarification—Seed scarification involves breaking, scratching, or softening the seed coat so that water can enter and begin the germination process. There are several methods of scarifying seeds.
   a. In acid scarification, seeds are put in a glass container and covered with concentrated sulfuric acid. The seeds are gently stirred and allowed to soak from 10 minutes to several hours, depending on the hardness of the seed coat. When the seed coat has become thin, the seeds can be removed, washed, and planted.
   b. Another scarification method is mechanical. You may file seeds with a metal file, rub them with sandpaper, or crack them with a hammer to weaken the seed coat.
   c. Hot water scarification involves putting the seed into hot water (170° to 212°F). The seeds are allowed to soak in the water, as it cools, for 12 to 24 hours and then planted.
   d. You also may try warm, moist scarification. In this case, seeds are stored in nonsterile, warm, damp containers where the seed coat will be broken down by decay over several months.
2. Seed stratification—Seeds of some fall-ripening trees and shrubs of the temperate zone will not germinate unless chilled underground as they overwinter. This so-called "after-ripening" may be accomplished artificially by a practice called stratification.
   a. The following procedure is usually successful. Put sand or vermiculite in a clay pot to about 1 inch from the top. Place the seeds on top of the medium and cover with 1/2-inch of sand or vermiculite. Wet the medium thoroughly and allow excess water to drain through the hole in the pot. Place the pot containing the moist medium and seeds in a plastic bag and seal. Place the bag in a refrigerator (not freezer). Periodically check to see that the medium is moist, but not wet. Additional water will probably not be necessary. After 10 to 12 weeks, remove the bag and pot from the refrigerator. Remove the bag and set the pot in a warm place in the house. Water often enough to keep the medium moist. Soon the seedlings should emerge. When the young plants are about 2 inches tall, transplant them into pots to grow until it is time to set them outside.
   b. Another procedure for starting seeds uses sphagnum moss or peat moss. Wet the moss thoroughly, then squeeze out the excess water with your hands. Mix seed with the sphagnum or peat and place in a plastic bag. Seal the bag and put it in a refrigerator. Check periodically. If there is condensation on the inside of the bag, the process will be successful. After 10 to 12 weeks, remove the bag from the refrigerator. Plant the seeds in pots to germinate and grow. Handle seeds carefully. Often the small roots and shoots are emerging at the end of the stratification period. Care must be taken not to break these off.

c. Temperatures in the range of 35° to 45°F are effective for stratification. Most refrigerators operate in this range. Seeds of most fruit and nut trees can be successfully germinated by these procedures. Seeds of peaches should be removed from the hard pit. Care must be taken when cracking the pits. Any injury to the seed itself can be an entry path for disease organisms.

D. Starting Seeds

1. Media—A wide range of materials can be used to start seeds, from plain vermiculite or mixtures of soilless media to the various amended soil mixes. With experience, you will learn to determine what works best under your conditions. However, keep in mind what makes a good germinating medium. It should be rather fine and uniform, yet well-aerated and loose. It should be free of insects, disease organisms, and weed seeds. It should also be of low fertility or total soluble salts and capable of holding and moving moisture by capillary action. One mixture that supplies these factors is a combination of 1/3 sterilized soil, 1/3 sand or vermiculite or perlite, and 1/3 peat moss. Do not use garden soil by itself to start seedlings; it is not sterile, it is often too heavy, and it will not drain well.
   a. The importance of using a sterile medium and container cannot be overemphasized. The home gardener can treat a small quantity of soil in an oven. Place the slightly moist soil in a heat-resistant container in an oven set at about 250°F. Use a candy or meat thermometer to ensure that the mix reaches a temperature of 180°F for 30 minutes. Avoid over-heating as this can be extremely damaging to the soil. Be aware that the soil will release very unpleasant odors in the process of sterilization. This treatment should prevent damping-off and other plant diseases, as well as eliminate potential plant pests.
   b. An artificial, soilless mix also provides the desired qualities of a good germination medium. The basic ingredients of such a mix are sphagnum peat moss and vermiculite, both of which are generally free of diseases, weed seeds, and insects. The ingredients are also readily available, easy to handle, lightweight, and produce uniform plant growth. "Peat-lite" mixes or similar products are commercially available or can be made at home using this recipe: 4 quarts of shredded sphagnum peat moss, 4 quarts of fine vermiculite, 1 tablespoon of superphosphate, and 2 tablespoons of ground limestone. Mix thoroughly. These mixes have little fertility, so seedlings must be watered with a diluted fertilizer solution soon after they emerge.
2. Containers—Flats and trays can be purchased or you can make your own from scrap lumber. A convenient size to handle would be about 12 to 18 inches long and 12 inches wide with a depth of about 2 inches. Leave cracks of about 1/8-inch between the boards in the bottom or drill a series of holes to ensure good drainage.
   a. You can also make your own containers for starting seeds by recycling such things as cottage cheese containers, the bottoms of milk cartons, or bleach containers and pie pans, as long as good drainage is provided. Wash growing containers and implements to remove any debris, then rinse in a solution of one part chlorine bleach to nine parts water. At least one company has developed a form for shaping newspaper into pots, and another has developed a method for the consumer to make and use compressed blocks of soil mix instead of pots.
   b. Clay or plastic pots can be used and numerous types of pots made of compressed peat are also on the market. Plant bands and plastic cell packs are also available. Each cell or minipot holds a single plant that reduces the risk of root injury when transplanting. Peat pellets, peat or fiber-based blocks, and expanded foam cubes can also be used for sowing.

3. Seeding—The proper time for sowing seeds for transplants depends upon when plants may safely be moved out-of-doors in your area. This period may range from 4 to 12 weeks before transplanting, depending upon the speed of germination, the rate of growth, and the cultural conditions provided. A common mistake is to sow the seeds too early and then attempt to hold the seedlings back under poor light or improper temperature ranges. This usually results in tall, weak, spindly plants that do not perform well in the garden.
   a. After selecting a container, fill it to within 3/4-inch of the top with moistened growing medium. For very small seeds, at least the top 1/4-inch should be a fine, screened mix or a layer of vermiculite. Firm the medium at the corners and edges with your fingers or a block of wood to provide a uniform, flat surface.
   b. For medium and large seeds, make furrows 1 to 2 inches apart and 1/8- to 1/4-inch deep across the surface of the container using a narrow board or pot label. By sowing in rows, good light and air movement results, and if damping-off fungus does appear, there is less chance of it spreading. Seedlings in rows are easier to label and handle at transplanting time than those that have been sown in a broadcast manner. Sow the seeds thinly and uniformly in the rows by gently tapping the packet of seed as it is moved along the row. Lightly cover the seed with dry vermiculite or sifted medium if they require darkness for germination. A suitable planting depth is usually about two to three times the diameter of the seed.
   c. Do not plant seeds too deeply. Extremely fine seeds such as petunia, begonia, and snapdragon are not covered, but lightly pressed into the medium or watered in with a fine mist. If these seeds are broadcast, strive for a uniform stand by sowing half the seeds in one direction, then sowing the remaining seed the other direction to form a crossed pattern.
   d. Large seeds are frequently sown into a small container or cell pack that eliminates the need for early transplanting. Usually two or three seeds are sown per unit and later thinned to allow the strongest seedling to grow.
4. Seed tape—Most garden stores and seed catalogs offer indoor and outdoor seed tapes. Seed tape has precisely spaced seeds enclosed in an organic, water-soluble material. When planted, the tape dissolves and the seeds germinate normally. Seed tapes are especially convenient for tiny, hard-to-handle seeds. However, tapes are much more expensive per seed. Seed tapes allow uniform emergence, eliminate overcrowding, and permit sowing in perfectly straight rows. The tapes can be cut at any point for multiple-row plantings, and thinning is rarely necessary.
   a. A homemade "seed tape" can be fashioned from 2-ply toilet paper and paste made with flour and water. Separate the two paper layers, then use a toothpick with a dab of flour paste on it to pick up and place seeds on one of the paper layers. Once all seeds are placed, put the two layers back together while the paste is still wet and roll the "tape" up for later use. The toilet paper, once covered with soil, will rapidly decay leaving no trace.
5. Pregermination—Another method of starting seeds is pregermination. This method involves sprouting the seeds before they are planted in pots or in the garden. This reduces the time to germination, as the temperature and moisture are easy to control. A high percentage of germination is achieved since environmental factors are optimum.
   a. Lay seeds between two paper towels or on a layer of vermiculite in a shallow pan. Keep them moist and in a warm place. When roots begin to show, place the seeds in containers or

plant them directly into the garden. While transplanting seedlings, be careful not to break off tender roots. Continued attention to watering is critical.

b. When planting seeds in a container that will be set out in the garden later, place one seed in a 2- to 3-inch container. Plant the seeds at only one-half the recommended depth. Gently press a little soil over the sprouted seed and then add about 1/4-inch of milled sphagnum peat or sand to the soil surface. These materials will keep the surface uniformly moist and are easy for the shoot to push through. Keep the seedlings in a warm place and care for them as for any other newly transplanted seedlings.

c. A convenient way to plant small, delicate, pregerminated seeds is to suspend them in a gel. You can make a gel by blending cornstarch with boiling water to a consistency that is thick enough so the seeds will stay suspended. Be sure to cool thoroughly before adding seeds. Place the gel with seedlings in a plastic bag with a hole in it. Squeeze the gel through the hole along a premarked garden row. Spacing of seeds is determined by the number of seeds in the gel. If the spacing is too dense, add more gel; if too wide, add more seeds. The gel will keep the germinating seeds moist until they establish themselves in the garden soil.

5. Watering—After the seed has been sown, moisten the planting mix thoroughly. Use a fine mist or place the containers in a pan or tray that contains about 1 inch of warm water. Avoid splashing or excessive flooding, which might displace small seeds. When the planting mix is saturated, set the container aside to drain. The soil should be moist but not wet.

   a. Ideally, seed flats should remain sufficiently moist during the germination period without having to add water. One way to maintain moisture is to slip the whole flat or pot into a clear plastic bag after the initial watering. The plastic should be at least 1 inch from the soil. Placing a popsicle stick or pencil in the middle of the flat will hold the plastic off the soil and plants. Keep the container out of direct sunlight, otherwise the temperature may rise to the point where the seeds will be harmed. Many home gardeners cover their flats with panes of glass instead of using a plastic bag. Be sure to remove the plastic or glass cover as soon as the first seedlings appear. Surface watering can then be practiced.

   b. Lack of uniformity, overwatering, or drying out are problems related to manual watering. Excellent germination and moisture uniformity can be obtained with a low-pressure misting system or subirrigation (watering from below). Flats or pots must not sit in water constantly as the soil may absorb too much water, and the seeds will rot due to lack of oxygen.

6. Temperature and light—Several factors for good germination have already been mentioned. The last item, and by no means the least important, is temperature. Since most seeds will germinate best at an optimum temperature that is usually higher than most home night temperatures, special warm areas must be provided. The use of thermostatically controlled heating cables is an excellent method of providing constant heat (see Germination section on page 3-2).

   a. After germination and seedling establishment, move the flats to a light, airy, cooler location, at a 55° to 60°F night temperature and a 65° to 70°F day reading. This will prevent soft, leggy growth and minimize disease. Some crops, of course, may germinate or grow best at a different constant temperature and must be handled separately from the rest of the plants. Read as much as you can about the plants you are trying to grow.

   b. Seedlings must receive bright light after germination. Place them in a window facing south, if possible. If a

large, bright window is not available, place the seedlings under a fluorescent light. Use two 40-watt, cool-white fluorescent tubes or special plant growth lamps. Position the plants 6 to 8 inches from the tubes and keep the lights on for 14 to 16 hours each day. As the seedlings grow, the lights should be raised.

E. Transplanting and Handling

If the plants have not been seeded in individual containers, they must be transplated to give them proper growing space. One of the most common mistakes made is leaving the seedlings in the seed flat too long. The ideal time to transplant young seedlings is when they are small as there is less danger from transplant shock. This is usually about the time the first true leaves appear above or between the cotyledons (the cotyledons sometimes called "seed leaves" are not true leaves). Avoid letting plants get hard, stunted, or tall and leggy.

1. Seedling growing mixes and containers can be purchased or prepared similar to those mentioned for germinating seed. The medium should contain more plant nutrients than a germination mix. Some commercial soilless mixes have fertilizer already added. When fertilizing, use a soluble houseplant fertilizer at the rate recommended by the manufacturer, about every 2 to 3 weeks after the seedlings are established. Remember that young seedlings can easily be damaged by too much fertilizer, especially if they are under moisture stress.
2. To transplant, carefully dig up the small plants with a knife or wooden plant label. Let the group of seedlings fall apart and pick out individual plants. Gently ease them apart in small groups that will make it easier to separate individual plants. Avoid tearing roots in the process. Handle small seedlings by their leaves, not by their delicate stems. Punch a hole in the medium into which the seedling will be planted. Make it deep enough so that the seedling can be put at the same depth it was growing at in the seed flat. After planting, firm the soil and water gently. Keep newly transplanted seedlings in the shade for a few days, or place them under fluorescent lights. Keep them away from direct heat sources. Continue watering and fertilizing as in the seed flats.
3. Most plants transplant well and can be started indoors, but a few plants are difficult to transplant. These are generally directly seeded outdoors or sown directly into individual containers indoors. Examples include zinnias and cucurbits, such as melons and squash.
4. Containers for transplanting—There is a wide variety of containers from which to choose for transplanting seedlings. These containers should be economical, durable, and make good use of space. The type selected will depend on the type of plant to be transplanted and individual growing conditions. Small plastic pots may be used, but they waste a great deal of space and may not dry out rapidly enough for the seedling to have sufficient oxygen for proper development.
   a. Many types of containers are available commercially. Those made out of pressed peat can be purchased in varying sizes. Individual pots are inexpensive and can be planted directly into the garden. When setting out plants grown in peat pots, be sure to cover the pot completely. If the top edge of the peat pot extends above the soil level, it may act as a wick and draw water away from the soil and roots. To avoid this, tear off the top lip of the pot and then plant.
   b. Compressed peat pellets, when soaked in water, expand to form compact, individual pots. They waste no space, don't fall apart as badly as peat pots, and can be set directly out in the garden.
   c. In addition, many homeowners find a variety of materials from around the house to use for containers. These homemade containers should be deep enough to provide adequate soil and

have plenty of drainage holes in the bottom.

5. Hardening plants—Hardening off is the process of altering the quality of plant growth to withstand the change in environmental conditions that occurs when plants are transferred from a greenhouse to the garden. Severe sunscald or a stoppage in growth may occur if plants produced in the home are planted outdoors without a transition period. Hardening off is most critical with early crops, when adverse climatic conditions can be expected.
   a. Hardening off can be accomplished by gradually lowering temperature and relative humidity and reducing water. This procedure results in an accumulation of carbohydrates and a thickening of cell walls. A change from a soft, succulent type of growth to a firmer, harder type occurs.
   b. This process should be started at least 2 weeks before planting in the garden. If possible, plants should be moved to a 45° to 50°F temperature either indoors or outdoors in a shady location. A coldframe is excellent for this purpose. When put outdoors, plants should be shaded, then gradually moved into sunlight. Start with a 15- to 20-minute exposure. Each day gradually increase the length of exposure time to outside temperatures. Don't put tender seedlings outdoors on windy days or when temperatures are below 45°F.
   c. Reduce the frequency of watering to slow their growth, but don't allow plants to wilt. Even cold-hardy plants will be hurt if exposed to freezing temperatures before they are hardened. After proper hardening, however, they can be planted outdoors and light frosts will not damage them.
   d. The hardening off process is intended to slow plant growth. If carried to the extreme of actually stopping plant growth, significant damage can be done to certain crops. For example, cucumbers and melons will stop all growth, while cauliflower will make thumb-size heads and fail to develop further if hardened too severely.

II. Asexual Propagation

Asexual propagation is the best way to maintain some species, particularly an individual that best represents that species. Clones are groups of plants that are identical to their parent or mother plant. The Bartlett pear (1770) and the Delicious apple (1870) are two examples of clones that have been asexually propagated for many years. The major methods of asexual propagation are cuttings, layering, division, and budding/grafting. Cuttings involve rooting a severed piece of the parent plant; layering involves rooting a part of the parent plant and then severing it later; and budding and grafting is joining two plant parts from different varieties.

A. Cuttings

Many types of plants, both woody and herbaceous, are frequently propagated by cuttings. A cutting is a vegetative plant part that is severed from the parent plant in order to regenerate itself, thereby forming a whole new plant.

1. Take cuttings with a sharp blade to reduce injury to the parent plant. Before using the knife to cut, dip the cutting tool into rubbing alcohol and allow it to dry or use a mixture of one part bleach to nine parts water to disinfect the blade and to prevent transmitting diseases. Remove flowers and flower buds from cuttings to allow the cutting to use its energy and stored carbohydrates for root and shoot formation rather than fruit and seed production.
   a. To hasten rooting, increase the number of roots, or to obtain uniform rooting (except on soft, fleshy stems), use a rooting hormone, preferably one containing a fungicide. Prevent possible contamination of the entire supply of rooting hormone by putting a small amount in a separate container for immediate use. Do not dip cuttings directly into the original container.

b. If hormone powder is used, only a very light coating is necessary. Tap off any excess onto a sheet of paper.

2. Insert cuttings into a rooting medium such as coarse sand, vermiculite, sterilized soil, water, or a mixture of peat and perlite. A pencil can be used to make a hole in the medium for easier insertion and to prevent the removal of hormone powder from the cut surface.
   a. It is important to choose the correct rooting medium to get optimum rooting in the shortest time. In general, the rooting medium should be sterile, low in fertility, drain well enough to provide oxygen, and retain enough moisture to prevent water stress. Moisten the medium before inserting cuttings, and keep it evenly moist while cuttings are rooting and forming new shoots. Place stem and leaf cuttings in indirect light. Root cuttings can be kept in the dark until new shoots appear.
3. Stem cuttings—Numerous plant species are propagated by stem cuttings (Table 2). Some can be taken at any time of the year, but stem cuttings of many woody plants must be taken during the fall or in the dormant season. Tip, medial, cane, single and double eye, and heel are all examples of stem cuttings.
   a. Tip cuttings: Detach a 2- to 4-inch piece of stem with two or three nodes, including the terminal bud. Make the bottom cut 1/4-inch below a node. Remove lower leaves from the cutting that would be in contact with the medium. Dip the stem in rooting hormone if desired. Gently tap the end of the cutting to remove excess hormone. Insert the cutting deeply enough into the media to support itself (about half way). At least one node must be below the surface.
   b. Medial cuttings: Make the first cut just above a node, and the second cut just below another node 2 to 4 inches down

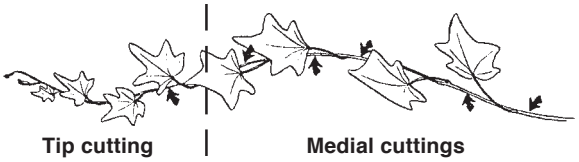
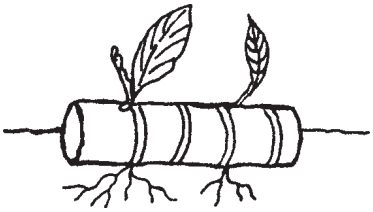


Table 2. Selected herbaceous plants that can be propagated from cuttings.

Plant		Type of cutting	Approximate time to root (weeks)*
Common name	**Scientific name**		
African violet	*Saintpaulia* spp.	leaf	3 to 4
Aluminum plant	*Pilea* spp.	stem	2 to 3
Aloe	*Aloe* spp.	leaf	4 to 6
Aphelandra	*Aphelandra* sp.	stem	2 to 3
Arrowhead plant	*Syngonium podophyllum*	stem	2 to 3
Begonia	*Begonia* spp.	stem (fibrous rooted)	2
		whole leaf or leaf section (Rex)	4 to 5
Cactus	*Cephalocereus senilis*	stem	3 to 4
	Opuntia microdasys	stem	3 to 4
Chrysanthemum	*Chrysanthemum* spp.	stem	1 to 2
Carnation	*Dianthus* spp.	stem	2 to 3
Coleus	*Coleus blumei*	stem	1 to 2
Crown of thorns	*Euphorbia splendens*	stem	4 to 5
Dahlia	*Dahlia* spp.	stem or leaf-bud	3 to 4
Dieffenbachia (dumbcane)	*Dieffenbachia* spp.	stem	4 to 6
Dracaena	*Dracaena* spp.	stem	3 to 4
Echeveria	*Echeveria* spp.	stem or leaf	4 to 6
Euphorbia	*Euphorbia* spp.	stem	4 to 6
Fittonia	*Fittonia* spp.	stem	2 to 3
Fuchsia	*Fuchsia* spp. (also hybrids)	stem	1 to 2
Geranium	*Pelargonium* spp.	stem	1 to 2
Hoya	*Hoya* spp.	stem	3 to 4
Hydrangea	*Hydrangea* spp.	stem	2 to 3
Impatiens	*Impatiens* spp.	stem	2 to 3



Cane cuttings



Heel cuttings



Single eye (left) and double eye (right) cuttings

the stem. The terminal bud is not necessary for this kind of stem cutting. Prepare and insert the cutting as you would a tip cutting. Be sure to position right side up. Axial buds are always above leaves.

c. Cane cuttings: Cut cane-like stems into sections containing one or two "eyes" or nodes. Dust ends with fungicide or activated charcoal. Allow to dry several hours. Lay horizontally with about half of the cutting below the media surface, eye facing upward. Cane cuttings are usually potted when roots and new shoots appear. This method is used with dumbcane (Dieffenbachia).

d. Single eye cuttings: The eye refers to the node. This is used for plants with alternate leaves when space or stock material are limited. Cut the stem about 1/2 inch above and 1/2 inch below a node. Place cutting horizontally or vertically in the medium.

e. Double eye cuttings: This is used for plants with opposite leaves when space or stock material is limited. Cut the stem about 1/2 inch above and 1/2 inch below the same node. Insert the cutting vertically in the medium with the node just touching the surface.

f. Heel cuttings: This method uses plant material with woody stems. Make a shield-shaped cut about halfway through the wood around a leaf and axial bud. Insert the shield horizontally into the medium.

4. Leaf cuttings—Leaf cuttings are used almost exclusively for a few indoor houseplants. Leaves of most other plants will either produce a few roots but no plant, or they just decay. Covering leaf cut-

Table 2. (cont'd)

Plant		Type of cutting	Approximate time to root (weeks)*
Common name	**Scientific name**		
Ivy	several genera and species	stem	2 to 3
Jade	*Crassula* spp.	stem or leaf	4 to 5
Kalanchoe (bryophyllum)	*Kalanchoe* spp.	stem or leaf	4 to 5
Lantana	*Lantana* sp.	stem	3 to 4
Monstera (Swiss cheese plant)	*Monstera deliciosa*	stem	4 to 5
Mint	*Mentha* spp.	stem	2 to 3
Peperomia	*Peperomia* sp.	leaf, leaf-bud or stem	4 to 6
	P. obtusifolia	leaf-bud or stem	4 to 6
	P. obtusifolia variegata	leaf-bud or stem	4 to 6
Periwinkle (myrtle)	*Vinca* spp.	stem	3 to 4
Petunia	Petunia hybrids	stem	2 to 3
Philodendron	*Philodendron* spp.	stem	2 to 4
Piggyback plant	*Tolmiea menziesii*	leaf with plantlet	3 to 4
Pothos	*Scindapsus aureus*	stem	2 to 3
Poinsettia	*Euphorbia pulcherrima*	stem	2 to 3
Sansevieria (snake plant)	*Sansevieria* spp.	leaf, leaf section	4 to 6
Velvet plant	*Gynura* spp.	stem	1 to 2
Wandering jew	*Tradescantia* spp. *Zebrina* spp.	stem	2 to 3

*The indicated time for rooting is only approximate and may be longer under some conditions. Where new shoots must develop in addition to roots, the time required for shoot development is often longer.

Source: Propagating Herbaceous Plants from Cuttings, PNW 151.

tings with a plastic bag will maintain moisture in the medium and humidity around the cutting.

a. Whole leaf with petiole: Detach the leaf and up to 1 1/2 inches of petiole. Insert the lower end of the petiole into the medium. One or more new plants will form at the base of the petiole. The leaf may be severed from the new plants when they have their own roots, and the petiole reused. This method is used for African violets.



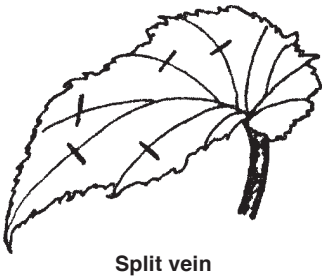
Whole leaf with petiole



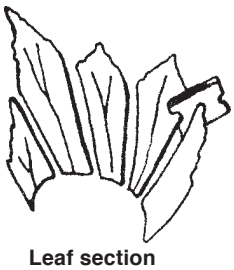
Whole leaf without petiole

b. Whole leaf without petiole: This is used for plants with sessile leaves. Insert the cutting vertically into the medium. A new plant will form from the axillary buds. The leaf may be removed when the new plant has its own roots. This method is used with jade plants.

c. Split vein: Detach a leaf from the stock plant. Slit its veins on the lower leaf surface. Lay and pin the cutting, lower side down, on the medium. New plants will form at each cut. If the leaf tends to curl up, hold it in place by covering the margins with the rooting medium. This method is used with Rex begonias. A plastic bag around the container and leaf will help keep the leaf from drying out.



Split vein



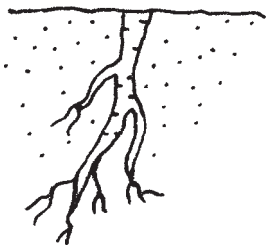
Leaf section

d. Leaf sections: This method is frequently used with snake plant (Sansevieria) and Rex begonias. Cut begonia leaves into wedges with at least one main vein. Lay leaves flat on the medium. A new plant will arise at the vein.

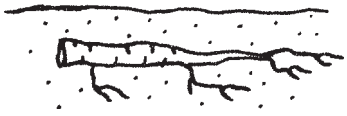
Cut snake plant leaves into 2-inch sections. Consistently make the lower cut slanted and the upper cut straight so you can tell which is the top. Insert the cuttings vertically into the medium. Eventually a new plant will appear at the base of the cutting. These and other succulent cuttings will rot if kept too moist. No plastic bag is needed around succulents.

5. Root cuttings—Root cuttings are usually taken from 2- to 3-year-old plants during their dormant season when they have a large carbohydrate supply. Root cuttings of some species produce new shoots, which then form their own root systems, while root cuttings of other plants develop root systems before producing new shoots.

a. Plants with large roots: Make a straight top cut and a slanted cut 2 to 6 inches below the first cut. This will help you determine what portion is the top. Store about 3 weeks in moist sawdust, peat moss, or sand at 40°F. Remove from storage. Insert the cutting vertically with the top approximately level with the surface of the rooting medium. This method is often used outdoors.



Plants with large roots



Plants with small roots

b. Plants with small roots: Take a 2- to 3-inch section of root. Insert the cutting horizontally about 1/2 inch below the medium surface. This method is usually used indoors or in a hotbed.

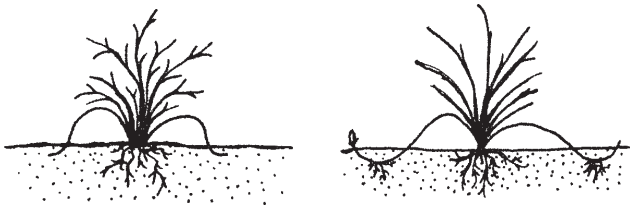
B. Layering

Stems still attached to their parent plants may form roots where they touch a rooting

medium. Severed from the parent plant later, the rooted stem becomes a new plant. This method of vegetative propagation, called layering, promotes a high success rate because it prevents water stress and the loss of carbohydrate shortage that plagues cuttings.

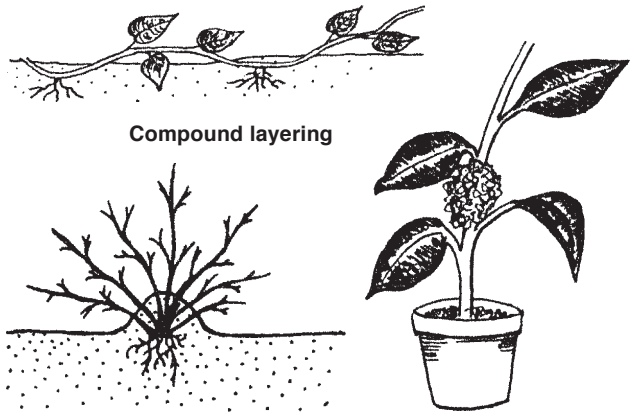
Some plants layer themselves naturally, but sometimes plant propagators assist the process. Layering is enhanced by wounding one side of the stem or by bending it very sharply.

1. Tip layering—Dig a hole 3 to 4 inches deep. Insert the shoot tip and cover it with soil. The tip grows downward first, then bends sharply and grows upward. Roots form at the bend, and the recurved tip becomes a new plant. Remove the tip layer from the mother plant and plant it in early spring or fall. Examples: purple and black raspberries and trailing blackberries.



Tip layering Simple layering

2. Simple layering—Bend the stem to the ground. Cover part of it with soil, leaving the last 6 to 12 inches exposed. Bend the tip into a vertical position and stake it in place. The sharp bend will often induce rooting, but wounding the lower side of the branch may help. Examples: rhododendron and honeysuckle.
3. Compound layering—This method works for plants with flexible stems. Bend the stem to the rooting medium as for simple layering, but alternately cover and expose stem sections. Wound the lower side of stem sections to be covered. Examples: heart-leaf philodendron and pothos.
4. Mound (stool) layering—Cut the plant back to 1 inch above the ground during the dormant season. Mound soil over the emerging shoots in the spring to enhance their rooting. Examples: gooseberries and apple rootstocks.



Compound layering

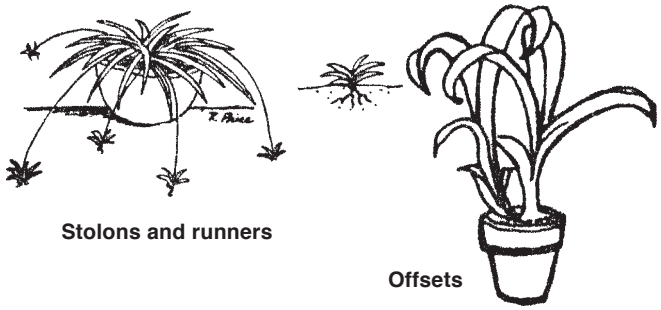
Mound layering Air layering

5. Air layering—Air layering is used to propagate some indoor plants with thick stems, or to rejuvenate them when they become leggy. Make an upward slanting cut one half way through the stem just below a node. Hold the slit open with a toothpick laid sideways or a bit of sphagnum moss. Surround the wound with wet, unmilled sphagnum moss. Wrap plastic or foil around the sphagnum moss and tie it in place above and below the wound. When roots pervade the moss, cut the plant off below the root ball. Examples: dumbcane and rubber tree.

Note: The following propagation methods can all be considered types of layering, as the new plants form before they are detached from their parent plants.

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6. Stolons and runners—A stolon is a horizontal, often fleshy stem that can root and produce new shoots where it touches the medium. A runner is a slender stem that originates in a leaf axil and grows along the ground or downward from a hanging basket, producing a new plant at its tip. Plants that produce stolons or runners are

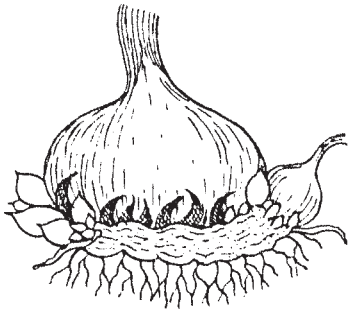


Stolons and runners

Offsets

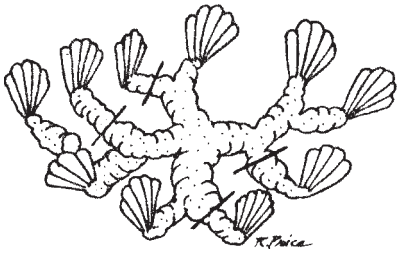
propagated by severing the new plants from their parent stems. Plantlets at the tips of runners may be rooted while still attached to the parent, or detached and placed in a rooting medium. Examples: strawberry and spider plant.

7. Offsets—Plants with a rosetted stem often reproduce by forming new shoots at their base or in leaf axils. Sever the new shoots from the parent plant after they have developed their own root system. Unrooted offsets of some species may be removed and placed in a rooting medium. Some of these must be cut off, while others may simply be lifted off of the parent stem. Examples: date palm, haworthia, bromeliads, and many cacti.
8. Separation—Separation is a term applied to a form of propagation by which plants that produce bulbs or corms multiply.
   a. Bulbs: New bulbs form beside the originally planted bulb. Separate these bulb clumps every 3 to 5 years for largest blooms and to increase bulb number. Dig up the clump after the leaves have withered. Gently pull the bulbs apart and replace them immediately so that their roots can begin to develop. Small, new bulbs may not flower for 2 or 3 years, but large ones should bloom the first year. Examples: tulip and narcissus.



Separation corms

   b. Corms: A large new corm forms on top of the old corm, and tiny cormels form around the large corm. After the leaves wither, dig up the corms and allow them to dry in indirect light for 2 or 3 weeks. Remove the cormels, then gently separate the new corm from the old corm. Dust all new corms with a fungicide and store in a cool place until planting time. Examples: crocus and gladiolus.



Division

C. Division

Plants with more than one rooted crown may be divided and the crowns planted separately. If the stems are not jointed, gently pull the plants apart. If the crowns are united by horizontal stems, cut the stems and roots with a sharp knife to minimize injury. Divisions of some outdoor plants should be dusted with a fungicide before they are replanted. Examples: snake plant, iris, prayer plant, and day lilies.

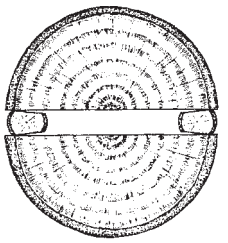
1. Most perennials left in the same place for more than 3 years are likely to be overgrown, overcrowded, have dead or unsightly centers, and in need of basic feeding and soil amendment. The center of the clump will grow poorly, if at all, and the flowers will be sparse. The clump will deplete the fertility of the soil as the plant crowds itself.
   a. To divide mature clumps of perennials, select only vigorous side shoots from the outer part of the clump. Discard the center of the clump. Divide the plant into sections of three to five shoots each. Be careful not to overdivide; too small a section will not give much color the first year after replanting.
   b. Divide perennials when the plants are dormant, just before a new season of growth, or in the fall so they can become established before the ground freezes.

D. Grafting

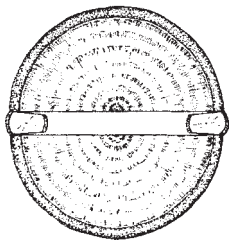
Grafting and budding are methods of asexual plant propagation that join plant parts so they will grow as one plant. These

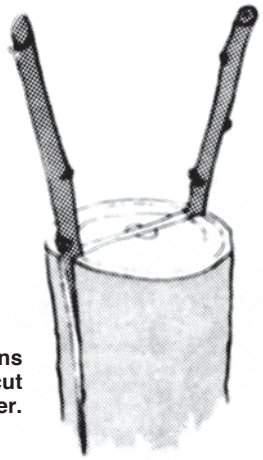
techniques are used to propagate cultivars that will not root well as cuttings or whose own root systems are inadequate. One or more new cultivars can be added to existing fruit and nut trees by grafting or budding.

1. The portion of the cultivar that is to be propagated is called the scion. It consists of a piece of shoot with dormant buds that will produce the stem and branches. The rootstock, or stock, provides the new plant's root system and sometimes the lower part of the stem. The cambium is a layer of cells located between the wood and bark of a stem from which new bark and wood cells originate.
2. Four conditions must be met for grafting to be successful: (1) The scion and rootstock must be compatible, (2) each must be at the proper physiological stage, (3) the cambial layers of the scion and stock must meet, and (4) the graft union must be kept moist until the wound has healed.
   a. Cleft grafting: Cleft grafting is often used to change the cultivar or top growth of a shoot or a young tree (usually a seedling). It is especially successful if done in the early spring. Collect scion wood 3/8- to 5/8-inch in diameter. Cut the limb or small tree trunk off at the area that it is to be worked. Make a 2-inch vertical cut through the center of the limb or trunk. Be careful not to tear the bark. Keep this cut wedged apart. Cut the lower end of each scion piece into a wedge. Prepare two scion pieces 3 to 4 inches long. Insert the scions at the outer edges of the cut in the stock. Tilt the top of the scion slightly outward and the bottom slightly inward to be sure the cambial layers of the scion and stock touch. Remove the wedge propping the slit open and cover all cut surfaces with grafting wax.



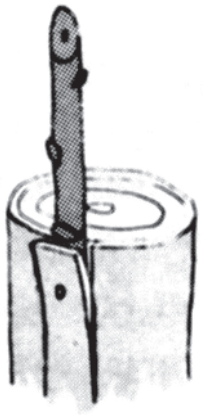
Cleft graft (correct method on top; incorrect method below)





Cleft graft with both scions inserted at slight angles. All cut surfaces should be waxed over.

   b. Veneer or bark grafting. Unlike most grafting methods, bark grafting can be used on large limbs, although these are often infected before the wound can completely heal. Collect scion wood 3/8- to 1/2-inch in diameter when the plant is dormant, and store the wood wrapped in moist paper in a plastic bag in the refrigerator. Saw off the limb or trunk of the rootstock to be worked. In the spring, when the bark easily separates from the wood, make a 1- to 2-inch diagonal cut on one side of the scion, and a 1 1/2-inch diagonal cut on the other side. Leave two buds above the longer cut. Slice through the bark of the stock cutting a little wider than the scion. Insert the scion between the bark and wood with the longer cut against the wood. Nail the graft in place with flat-headed wire nails. Cover all wounds with grafting wax.



Bark graft

   c. Whip or tongue grafting: This method is often used for material 1/4- to 1/2-



Whip or tongue graft

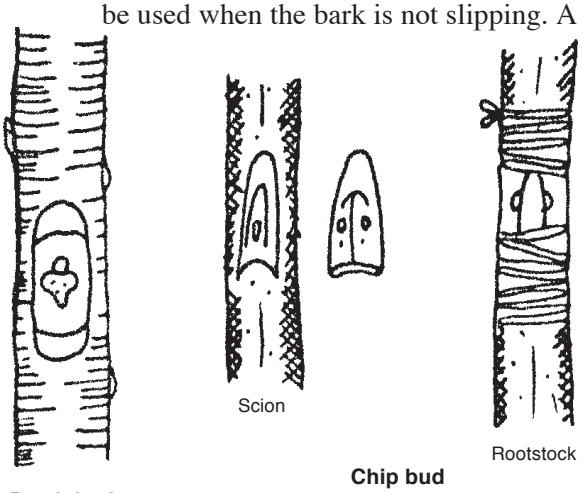
inch in diameter. The scion and rootstock are usually of the same diameter, but the scion may be narrower than the stock. This strong graft heals quickly and provides excellent cambial contact. Make one 2 1/2-inch sloping cut at the top of the rootstock and a matching cut on the bottom of the scion. On the cut surface, slice downward into the stock and up into the scion so the pieces will interlock. Fit the pieces together, then tie and wax the union.

3. Care of the graft—Very little success in grafting will be obtained unless proper care is maintained for the following year or two. If a binding material such as strong cord or nursery tape is used on the graft, this must be cut shortly after growth starts to prevent girdling. Rubber budding strips have some advantages over other materials. They expand with growth and usually do not need to be cut, as they deteriorate and break after a short time. It is also an excellent idea to inspect the grafts after 2 or 3 weeks to see if the wax has cracked, and if necessary, rewax the exposed areas. After this, the union will probably be strong enough and no more waxing will be necessary.
4. Limbs of the old variety that are not selected for grafting should be cut back at the time of grafting. The total leaf surface of the old variety should be gradually reduced as the new grafted variety increases until at the end of 1 or 2 years, the new variety has completely taken over. Completely removing all the limbs of the old variety at the time of grafting will increase the shock to the tree and cause excessive suckering. Also, the scions may grow too fast, making them susceptible to wind damage.

E. Budding

Budding, or bud grafting, is the union of one bud (attached to a small piece of bark) from the scion to the rootstock. It is especially useful when scion material is limited. It is also faster and forms a stronger union than grafting.

1. Patch budding—Plants with thick bark should be patch budded. This is done while the plants are actively growing, so their bark slips easily. Remove a rectangular piece of bark from the rootstock. Cut a matching rectangular piece with a bud and piece of bark from the scion to cover this wound. If the rootstock's bark is thicker than that of the scion, pare it down to meet the thinner bark so that when the union is wrapped, the patch will be held firmly in place.
2. Chip budding—This budding method can be used when the bark is not slipping. A downward cut is made at a 45 degree angle about one quarter through the rootstock. About 1 inch above the first cut, a second cut is made slicing downward and inward until it connects with the first cut. The cuts removing the bud from the bud

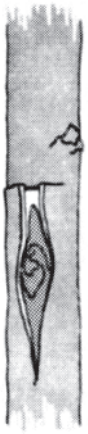


Patch bud

Chip bud

stick are made just as those in the rootstock, except the lower cut is made about 1/4-inch below a bud. Fit the bud chip to the stock and wrap the union.

3. T-budding—This is the most commonly used budding technique. When the bark is slipping, make a vertical cut through the bark of the rootstock, avoiding any buds on the stock. Make a horizontal cut at the top of the vertical cut (in a T shape) and loosen the bark by twisting the knife at the intersection. Remove a shield-shaped piece of the scion, including a bud, bark, and a thin section of wood. Push the shield under the loosened stock bark. Wrap the union, leaving the bud exposed.


T-bud

Care of buds—Place the bud in the rootstock in August. Force the bud to develop the following spring by cutting the stock off 3 to 4 inches above the bud. The new shoot may be tied to the resulting stub to prevent damage from the wind. After the shoot has made a strong union with the stock, cut the stub off close to the budded area.

F. Plant Tissue Culture

Tissue culture is a mass of undifferentiated callus tissue growing on an artificial medium, separately from the plant from which it originated. Size increases by cell division. After about 4 to 6 weeks, the mass of cells is large enough to divide into sections and reculture to produce additional tissue cultures. This procedure is usually done in a laboratory or under laboratory conditions.

A tissue culture can be started from a variety of plant parts that have cells capable of dividing. Usually tissues near the vascular area of stems and roots proliferate best, but cultures have been started from fruits, endosperm, pollen, and embryos. To read more about this exciting method of propagation refer to books in your local library.

Further Reading

Books

The Virginia Master Gardener Handbook, Virginia Cooperative Extension Service, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

The Nevada Master Gardener Handbook, University of Nevada Cooperative Extension, phone 702/784-4848.

Wilkins, H. M. 1988. *Plantwatching: How Plants Live, Feel, and Work*. MacMillan Co., New York, NY.

Wilkins, H. M. 1988. *Plantwatching: How Plants Remember, Tell Time, Form Partnerships, and Move*. Facts on File Publications, New York, NY.

Booklets and Pamphlets

University of Idaho Extension

CIS 869 Controlling Sunscald on Trees and Vines

PNW 496 Grafting and Budding Plants to Propagate, Topwork, Repair

CIS 866 Homeowner's Guide to Fruit Tree Fertilization

CIS 881 Success with Very Small Seeds

PNW 121 Nutrient Disorders in Tree Fruits (online only)

PNW 164 Propagating from Bulbs, Corms, Tubers, Rhizomes, and Tuberous Roots and Stems

PNW 151 Propagating Herbaceous Plants from Cuttings

PNW 170 Propagating Plants from Seed

CIS 1043 Selecting Grape Cultivars and Planting Sites in Idaho

PNW 400 Training and Pruning Your Home Orchard

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Chapter 5
Soils and Fertilizers

Valdasue Steele, Extension Educator, Benewah County

I. The Five Soil Forming Factors

What is soil? Soil is basically weathered rock, decaying remains of living organisms—plants and animals—and microorganisms. Soil is also commonly described as a medium for plant growth because it provides physical support and nutrients for plants.

Have you ever noticed how soils can vary within a short distance as well as regionally? Five soil forming factors are at work on all soils and determine their physical and chemical properties. Where all five factors are the same we can expect the soils will be very similar. The following is a description of the soil forming factors: parent material, climate, topography, living organisms, and time.

A. Parent Material

The term parent material refers to where the soil came from. The source of the soil has a large influence on soil texture, or particle size, and minerals present. Soil surveys include the parent materials in the soil descriptions; therefore, it is important to learn the common terms.

There are six basic types of parent material:

1. Alluvium—Parent material that has been transported by water, such as in flood plains and washes.
2. Colluvium—Parent material that has been transported by gravity (talus), such as in toeslopes or debris at the base of a cliff.
3. Eolian—Parent material composed of sand-sized particles that have been transported by the wind.
4. Loess (pronounced "luss")—Parent material composed of silt sized particles that have been transported by the wind. The Palouse area of northern Idaho and eastern Washington is a good example of a loess deposit.
5. Lacustrine and marine sediments—Parent material that has been deposited by streams into freshwater lakes or ponds is lacustrine. Parent material that has been deposited by oceans or seas, sometimes found in salt-water basins, is marine.
6. Residual/residuum—parent material that has weathered, in place, from the bedrock below. These materials have not been transported.

B. Climate

Temperature and precipitation are major factors influencing the rate of weathering of a soil. They also control the rate of chemical and physical processes. Water is the medium by which things are moved into and through a soil profile.

Less annual precipitation means that soluble components, such as calcium carbonate (lime), will accumulate, which is why soils in arid regions are more alkaline. Conversely, soils in high-moisture areas will have faster rates of leaching, or removal, of soluble components, which is why soils in humid regions are more acidic.

C. Topography

Topography includes both the gradient (steepness) of a slope and the aspect (direction) of the slope. The gradient influences how quickly water enters the soil or runs off, which directly influences the amount of soil loss or erosion. The aspect of the slope influences the amount of solar radiation and temperature fluctuations in the soil, which directly influences the type of plants that will grow in the soil.

D. Living Organisms (Biota)

Living organisms include plants, animals, and microorganisms that live in and on the soil. Biota have a significant impact on soil formation due to factors such as nutrient cycling, production of organic matter, and vegetative cover of the soil surface. Human activities such as farming and construction also impact the soil.

E. Time

How "old" a soil is makes a difference in its development. Soils are dynamic in that they are "a work in progress," constantly under the influence of the soil forming factors. The older a soil is, the more "developed" it is. Therefore, "young" soils are very different from "old" soils chemically and physically. An example of a young soil would be new soil deposits from a flood.

Each of the five soil forming factors has a powerful influence on the characteristics of a soil. This helps explain why soils a very short distance apart can be different. It takes a change in only one of the five soil forming factors to differentiate the classification of one soil from another's.

The consistency of the soil forming factors is demonstrated in a soil survey. Most soil surveys are done by county, and they are a good source of general soils information, including information on climate and land-use suitability.

The first step in developing a soil survey is to gather topographic data on the area to be surveyed. Lines are drawn to delineate areas of similar slope, and major changes in vegetation are noted. Each delineated area, or mapping unit, is then given a soil classification designation or name. A soil scientist will do field work to verify a few of these mapping units. Extrapolations can be made without field verification because the soil forming factors have such consistent effects on soil characteristics.

II. Major Components of a Mineral Soil

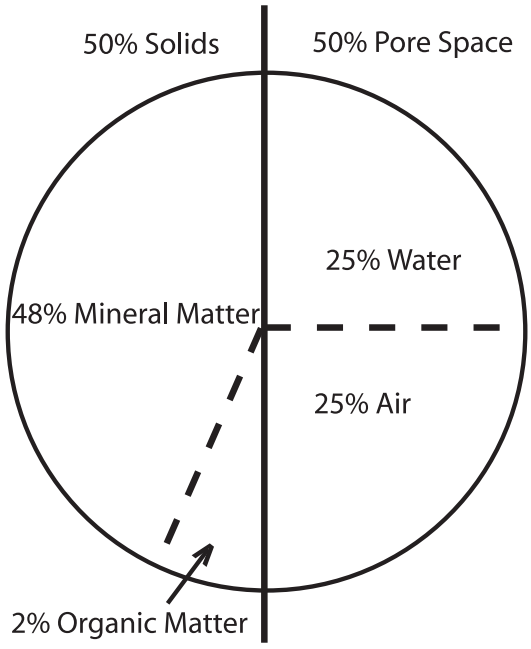
Only 48% of the soil is made up of minerals; the other 52% is organic matter and pore space filled with water or air (fig. 1). Water is the medium of transport for nutrients to reach the plant roots. Air is required for chemical processes in the plant roots as well as for the microorganisms that live in the soil. Too much water can not only cause the plants to die but can kill microorganisms as well. Generally, the mineral soils in Idaho have about 2% organic matter, plus or minus 2 to 3% in some areas of the state. That 2% organic matter affects the soil's water-holding capacity, soil structure, and fertility. Every bit of organic matter counts.

There is a vast array of microorganisms living in the soil. Microorganisms play a major role in nutrient cycling—the retention and release of nutrients in the soil. The main categories of microorganisms are listed below, with a conservative estimate of their concentration in soil:

- Bacteria –> 500 million per gram of soil
- Actinomycetes –> 1 to 20 million per gram of soil
- Fungi –> large variation up to 1 million per gram of soil
- Algae –> up to 500,000 per gram of soil
- Protozoa –> up to 500,000 per gram of soil
- Nematodes –> 50 or more per gram of soil

Have you ever noticed the smell of freshly tilled soil? That is the smell of microorganisms at work!

Fig. 1. Major components of a mineral soil. The percentage will vary depending on the soil. Under wet conditions, there is less air. Under dry conditions there is less water.



III. Soil Texture

The texture (particle size distribution) of a soil is determined by the relative amounts of sand, silt, and clay present. There are many possible combinations of these particles and distinct textural classes to describe all possible particle size combinations, or distributions. See the soil texture triangle (fig. 2) to determine the textural class of a particular soil. The three major particle size classes are sand, silt, and clay.

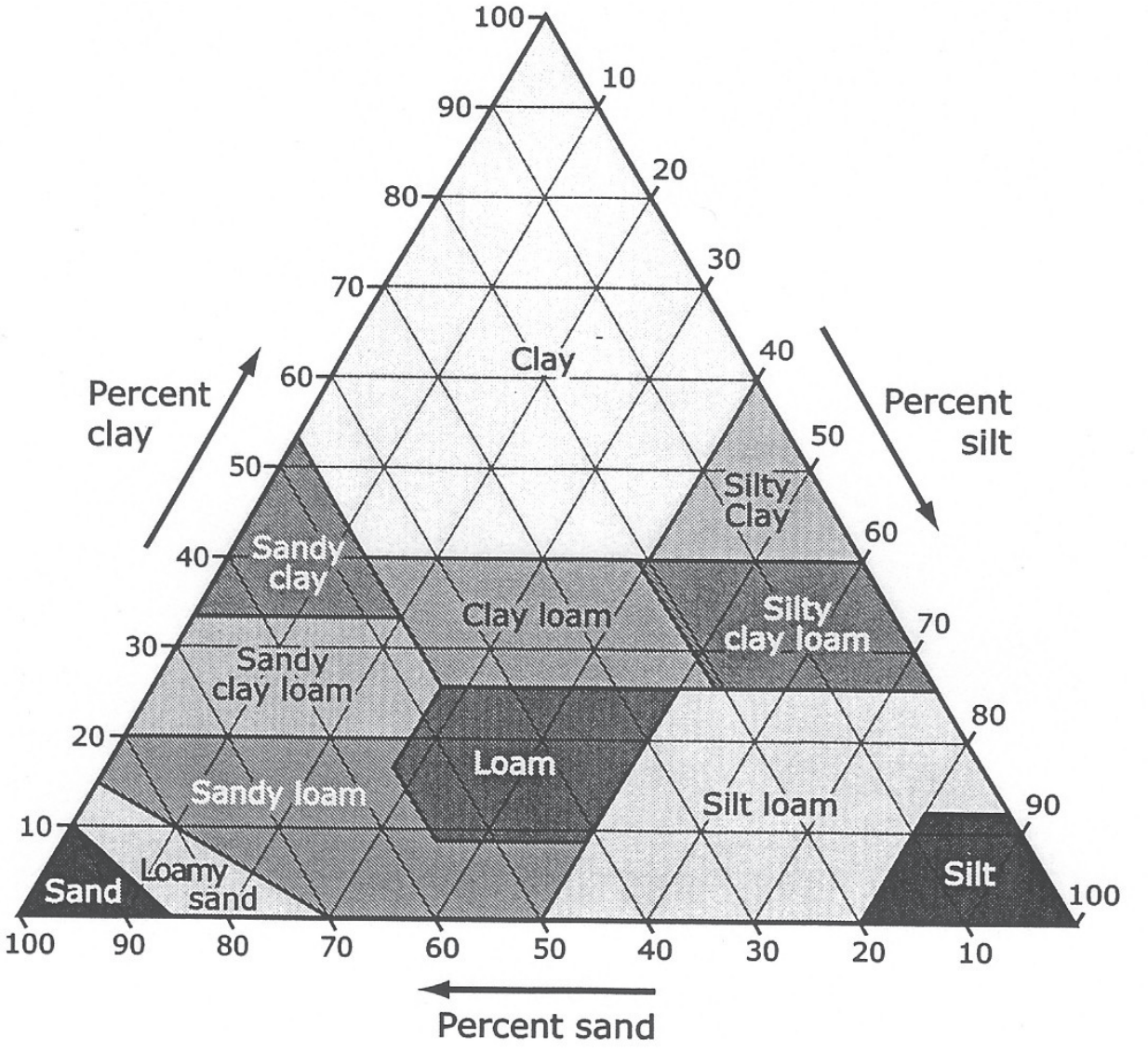
A. Sand

Sand particles range in size from 2.0 to 0.02 millimeters (mm). Sand particles are the largest particles in the soil. Any particle larger than the sand particle (>2 mm) is considered part of the rock fraction (gravel, stone, cobble, etc.), not part of the soil. Sand particles provide the most stable medium for engineering purposes. Sand particles are relatively inactive chemically. The large spaces between the particles (pore space) mean that water and some nutrients cannot be retained very long and readily move out of the soil profile. This is why sandy soil is often referred to as a "droughty" soil.

B. Silt

Silt particles range in size from 0.02 to 0.002 mm. Silt particles carry a very weak negative charge and are capable of holding small amounts of plant nutrients. Silty soils hold more water than sand, and water movement through silty soils is generally slower. A good example of silt is talcum powder.

Fig. 2. Soil texture triangle.



C. Clay

Clay particles are smaller than 0.002 mm, and there are many types of clays. Clay particles carry negative charges capable of attracting all positively charged ions in the soil; as a consequence, clays attract positively charged plant nutrients. The very tiny, flat clay particles lead to high water-holding capacity and can result in slow movement of water through the soil. Although there may be more total pore space in a given volume of clay soil than in sandy soil, most of the pore space in a clay soil will hold water. In contrast, most of the pore space in sand is large so water moves through rapidly rather than being held. Compaction can be a problem in clay soils more so than in sandy soils.

D. Texture and Soil Management

By knowing the texture of a soil and understanding the influences of sand, silt, and clay on the soil, you can make inferences about the management of that soil. Soils with a high sand content will need to be watered more often than soils with a high clay content. Soils with a high clay content have to be watered less often or there is a risk of waterlogging the soil.

A loam does not have equal percentages of the three soil separates (sand, silt, and clay) but is influenced by them equally. A loam has the characteristics of a clay for water- and nutrient-holding capacities, while the sand and silt provide pore space for air and water movement. Notice that a small amount of clay can strongly influence the soil texture class (fig. 2).

IV. Soil Structure

The arrangement of soil particles or aggregates is referred to as soil structure. Soil structure is the aggregation of sand, silt, and clay into shapes with distinct sizes and strengths (fig. 3). Soil structure provides additional pore space and open channels for movement of water, nutrients, air, and plant roots. Soil structure can give an indication of the age of the soil, parent material, vegetation, and land use.

Fig. 3. Various types of soil structures.



Granular: Resembles cookie crumbs usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.

Blocky: Irregular blocks usually 1.0-5.0 cm in diameter.

Columnar: Vertical columns that have a salt "cap" at the top. Found in soils of arid climates.

Platy: Thin, flat plates that lie horizontally. Usually found in compacted soil.

Prismatic: Vertical columns that might be a number of cm long. Usually found in lower horizons.

Single grained: Individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.

Soils that have organic matter and are properly managed will have good soil structure. If soils are cultivated when they are too wet, they can become very compacted and lose structure until reaggregation occurs. Plant roots and the addition of organic matter to the soil will help improve soil structure or tilth (soil workability).

V. Organic Matter

Organic matter in soil is made up of the remains of plants and animals. Residue from previous crops must be broken down to provide soil fertility and structure benefits. Moist and warm soil is ideal for microbes to work at breaking down plant tissue.

The organic matter content of a soil is an important factor related to overall productivity for the following reasons:

- Contributes to well-structured soil
- Is a source of three nutrients—nitrogen, phosphorus, and sulfur
- Increases water-holding capacity
- Increases soil aeration
- Provides an energy source for soil microorganisms (plants and animals)

VI. Carbon:Nitrogen (C:N) Ratio

The carbon:nitrogen (C:N) ratio is an important consideration whenever you add organic material to your production system (table 1). Plant residues and manures are made up largely of the following:

- Sugars, starches, and simple proteins that decompose rapidly
- Crude proteins
- Hemicelluloses
- Celluloses
- Lignin, fats, waxes, etc., that decompose slowly

Their rates of decay and release of nutrients to the soil vary greatly, as do the demands of living soil microorganisms as they "break down" plant residue.

In order to break down the carbon compounds in the plant tissue, microorganisms consume N. If the C:N ratio in the organic material is too high, greater than 25:1, there will be a net loss of nitrogen available for plant growth in the short term because the microorganisms will consume any N added with the organic material. On the other hand, if the C:N ratio is low, less than 20:1, sufficient N will be available to meet the microorganism's needs with some left over for plant growth. Thus organic material such as straw (C:N = 80:1) added to the soil will need to have N added with it or the plants will suffer.

Table 1. Carbon: Nitrogen ratio of common organic materials.

Material	C:N
Wheat straw	80:1
Pine needles	90:1
Sawdust	625:1

VII. Soil/Water Relationships

A. Water-Holding Capacity

One of the main functions of soil is to store moisture and supply it to plants between rainfalls or irrigations. Water in the soil is held in pores, the spaces between soil particles. If the soil's water content becomes too low, plants become stressed.

The water-holding capacity of a soil, and the amount of water available for plants to use, is dependent on the number and size of its pore spaces, which is directly related to soil texture and organic matter content. Water is held by the soil in various ways, and not all water in the soil is available to plants (table 2).

Capillary water is held in pores that are small enough to hold water against gravity but not so tightly that roots cannot absorb it. This water occurs as a film around soil particles and in the pores between them and is the main source of moisture for plants. As this water is withdrawn, the larger pores drain first. The finer the pores, the more resistant they are to removal of water. Capillary water can move in all directions for several feet as the particles and pores of the soil act like a wick.

When soil is saturated, all the pores are full of water and the water that drains out of the soil in the first few hours is called **gravitational water.** Gravitational water is available to plants only for a short time. When the gravitational water is gone, the soil is at **field capacity**. Plants then draw water out of the capillary pores until no more can be withdrawn and the only water left is in the micropores. The soil is then at the **wilting point**, and if water is not added to the soil, plants will die.

Table 2. Water-holding capacity of main soil texture groups (inches per foot).

Texture	Field capacity	Wilting point	Available water
Sand	1.3	0.6	0.7
Sandy Loam	2.5	1.3	1.2
Loam	3.6	1.8	1.8
Silt Loam	4.4	2.3	2.1
Clay Loam	4.6	2.6	2.0
Clay	4.7	2.8	1.9

Note: Figures are averages and vary with structure and organic matter.

A soil dominated by large particles (sand) has a lower water-holding capacity than a soil dominated by small particles (clay). Although a soil dominated by fine particles can hold more water, that water is not necessarily available (wilting point) because it takes more energy for plants to remove the water from the tiny pores.

B. Water Infiltration Rate

Infiltration specifically refers to water movement into the soil from the surface. The rate of infiltration is measured in inches (or cm) per hour. The finer the soil texture (more clay), the slower the infiltration rate and vice versa. The infiltration rate of a soil will determine how much and how often to apply water. The infiltration rate also affects how much rainfall or irrigation water will enter the soil or run off, which relates to erosion hazard.

C. Permeability Rate

Permeability specifically refers to water movement within and through the soil profile (after infiltration). The permeability rate is the speed at which water moves in the soil profile and like infiltration is measured in inches (or cm) per hour. Soil compaction, plow layers, hard pans, clay layers, rock, or changes in soil texture all can influence the permeability rate of the soil. When a homeowner seeks a permit to have an on-site septic leach field a "perc test" is required. This is a test of the permeability rate of the soil. If the rate is too slow then the site is not suitable for a septic leach field.

D. Soil Compaction

Compacted soils have low water infiltration/permeability rates. When the soil air spaces are compacted there is less space for air and water. Compacted soils also make root penetration and plant growth more difficult. Compaction can best be avoided by keeping heavy equipment off the soil when it has a high moisture content. Soil compaction can be remedied mechanically with deep tillage equipment.

E. Water & Air

Under irrigated conditions, regulating the soil water (moisture level) is an important management consideration. Excessive soil moisture, or saturated conditions, can be as harmful as limited-water conditions. Soil pore space and soil temperature are directly related to soil water content. For instance, a wet soil takes longer to warm up and will have a greater incidence of fungal and bacterial plant diseases.

Plant roots need oxygen and get it from the air in the soil pore space. When a soil is saturated, water displaces all the air in the pore space. If the wet condition persists, plant roots will die from lack of oxygen.

F. Nutrient Leaching

Leaching can best be described as the "flushing" of water and soluble nutrients out of the soil profile, specifically, out of the plant root zone. Factors that affect the rate of leaching in soils include:

- Amount of rainfall/irrigation
- Intensity (rate) of rainfall/irrigation
- Soil texture
- Quantity and type of clay minerals present
- Amount of organic matter

G. Soluble Salts

Soluble salts are described in terms of soil salinity and are measured by determining the electrical conductivity of a soil extract (EC). Salinity problems can occur where there are excessive applications of fertilizer, fresh manure, wood ash, or irrigation water or in areas with high water evaporation. High soil salinity is detrimental to plant growth.

VIII. pH

The term pH refers to the concentration of hydrogen ions (H^+) present in the soil. As the concentration of H^+ increases, the soil becomes more acidic. As the concentration decreases, the soil becomes more basic (alkaline). The pH scale is 0 (acidic) to 14 (alkaline). A pH of 7 is considered neutral. The pH scale is logarithmic:

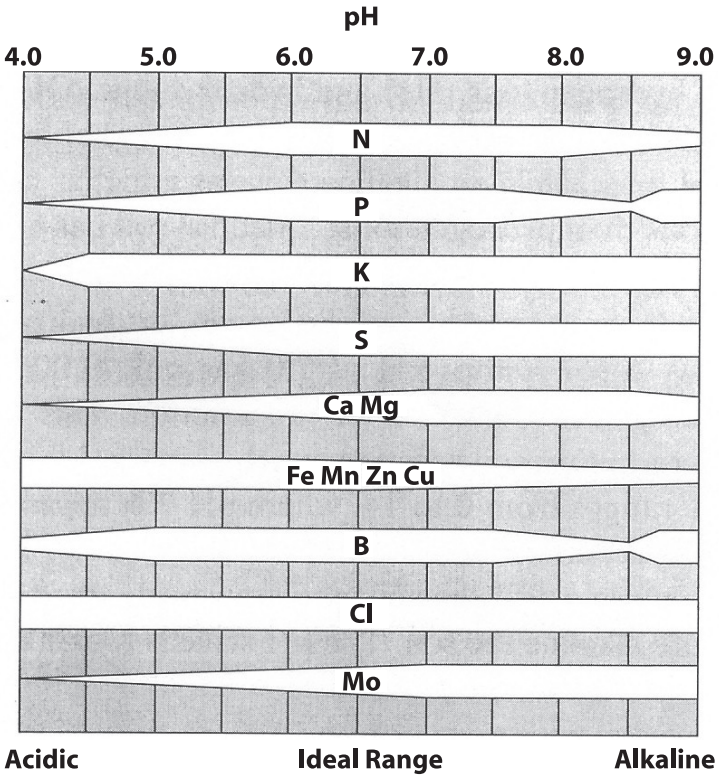
- pH 8—10 times more alkaline than pH 7
- pH 7—Neutral
- pH 6—10 times more acidic than pH 7
- pH 5—100 times more acidic than pH 7
- pH 4—1,000 times more acidic than pH 7

Plant species have various adaptations to specific acidic, neutral, or alkaline soil conditions. When plants fail to thrive, even after a fertilizer application, it may be an indication that there is a pH problem.

When pH is too low, applied lime can raise the pH. When pH is too high, applied sulfur can lower the pH. The change will be only temporary, however. Eventually, the soil pH will go back to what it was originally if amendments are not applied regularly. This ability of the soil to chemically revert to the way it was is referred to as buffering capacity. A soil that is high in clay content has a greater buffering capacity and will require a larger quantity of an amendment, such as lime, to change the pH. A sandy soil will require less lime to change the pH.

Soil pH greatly affects the availability of nutrients in the soil for plants to utilize. When pH is too acidic or alkaline then nutrients become unavailable to plants (fig. 4).

Fig. 4. Relative availability of nutrients as affected by soil pH. The bar width for each nutrient indicates its relative availability to plants at a particular pH. The wider the bar, the more available the nutrient.



IX. Plant Nutrients

A. Essential nutrients

Plants obtain from the soil 14 of the 17 elements essential to their growth. The other three elements—carbon, hydrogen, and oxygen—come from the water and from the air.

1. Macronutrients— Large quantities are required. Nitrogen generally is for leaf or vegetative growth, phosphorus is for root and fruit production, and potassium is for cold hardiness, disease resistance, and general durability.

a. Primary macronutrients

- Nitrogen (N)
- Phosphorus (P or in fertilizers, designated as phosphate, P_2O_5)
- Potassium (K or in fertilizers, designated as potash, K_2O)

b. Secondary macronutrients

- Calcium (Ca)
- Magnesium (Mg)
- Sulfur (S)

2. Micronutrients—Small quantities are required. Deficiencies in these nutrients are less common.
   - Boron (B)
   - Iron (Fe)
   - Molybdenum (Mo)
   - Chlorine (Cl)
   - Copper (Cu)
   - Manganese (Mn)
   - Zinc (Zn)
   - Nickel (Ni)

B. Functions of Macronutrients

1. Nitrogen (N)—Nitrogen can be taken up by plants as ammonium (NH_4^+) or nitrate (NO_3^-). Nitrogen is essential for the synthesis of proteins. It is essential to chlorophyll, which gives green color to plants; induces rapid vegetative growth; increases yields of leaf, fruit, or seed; improves quality of leaf crops; increases protein content of food and feed crops; and feeds soil microorganisms. Nitrogen tends to extend the length of the plant's maturity period, but too much will cause plants to fall over.
2. Phosphorus (P)—Phosphorus plays an important role in the metabolic processes of the cells such as cell division and expansion, respiration, and photosynthesis. In addition, phosphorus is important for early root growth and development. Phosphorus is significant in plant reproductive functions such as reducing the maturity period and stimulating flowering and seed formation. For some species, phosphorus improves winter hardiness.
3. Potassium (K)—Potassium is vital to water relations in the plant. It is responsible for movement of water in and out of the guard cells that open and close the stomata and the movement of water in and out of the plant leaf. It also serves as a nutrient regulator; increases vigor, strength, and disease resistance; makes stalks and stems stronger; helps early roots form and grow; and improves winter hardiness.
4. Sulfur (S)—As part of several amino acids, sulfur is essential for protein synthesis. It is also involved in nodule formation and nitrogen fixation in legumes.
5. Calcium (Ca)—Calcium aids in the development of leaves and roots. It is an essential part of the cell wall structure and must be present for the formation of new plant cells.
6. Magnesium (Mg)—Magnesium is essential for photosynthesis because it is the central atom in the chlorophyll molecule. Magnesium is also involved in phosphate metabolism and plant respiration and serves as an activator for many plant enzymes required in growth processes.

C. Functions of Micronutrients

The content of micronutrients in the soil is variable, as is their availability to plants. Soil pH is a significant factor in micronutrient availability. In very acidic soils, micronutrients can be toxic to plants.

1. Boron (B)—Boron is probably the most commonly deficient micronutrient. Boron is essential for germination of pollen grains, growth of pollen tubes, and formation of seeds and cell walls. Boron may also be involved in carbohydrate transport.
2. Chlorine (Cl)—Chlorine, usually as the chloride ion, is active in the energy reactions of the plant, specifically in the breakdown of water during photosynthesis. Chloride is present in the stomatal guard cells that regulate the loss of water from leaves through transpiration. Chloride has also been linked to increased resistance to fungal diseases in roots.
3. Copper (Cu)—Copper is necessary for chlorophyll production and may play a part in vitamin A production. Copper is also a component of several plant enzymes.
4. Iron (Fe)—Iron is a catalyst of chlorophyll formation and acts as a carrier of oxygen. It is also involved in the formation of some respiratory enzymes.
5. Manganese (Mn)—Manganese is part of the enzyme systems and metabolic reactions of the plant. It is also directly involved in the synthesis of chlorophyll.

6. Molybdenum (Mo)—Molybdenum is required in the smallest quantity of all the essential nutrients. Plants need it to use nitrogen, particularly for nitrogen fixation in the root nodules found on legumes.
7. Nickel (Ni)—Nickel is the most recent nutrient to be added to the essential nutrient family. It is an important component in nitrogen metabolism, particularly in the conversion of urea to ammonia.
8. Zinc (Zn)—Zinc is necessary for the production of chlorophyll and carbohydrates. Zinc is involved in the synthesis of plant growth hormones and in some metabolic reactions.
9. NOTE: Cobalt (Co) is not considered an essential nutrient, but root-nodule-forming bacteria in legumes need it for fixing nitrogen.

D. General Nutrient Deficiency Symptoms

Nutrient deficiency symptoms are an indication of severe starvation. A nutrient deficiency will limit plant production before deficiency symptoms actually show. Deficiency symptoms are sometimes difficult to distinguish visually and may resemble disease or insect problems.

General nutrient deficiency symptoms are categorized here according to whether or not the nutrient is translocated in the plant. Deficiencies of translocated nutrients exhibit symptoms in the lower, or older, leaves because the nutrients are mobilized and moved to new, growing parts of the plant.

1. Translocated Nutrients
   a. Nitrogen—Plants are light green in color; older leaves yellow starting at the leaf tips.
   b. Phosphorus—Plants are small and dark green with purple coloration.
   c. Potassium—Yellow or brown discoloration appears along the outer margins of the older leaves.
   d. Magnesium—Yellow discoloration occurs between the leaf veins. Reddish-purple discoloration extends from the outer edge of the leaf inward.
2. Non-Translocated Nutrients—Terminal Bud Dies
   a. Calcium—Primary leaf emergence is delayed, and terminal buds deteriorate.
   b. Boron—Leaves near the growing point (meristem) are yellow, and buds look like white or light brown dead tissue.
3. Non-Translocated Nutrients–Terminal Bud Remains Alive
   a. Sulfur—The whole leaf turns pale green to yellow starting with the younger leaves.
   b. Zinc—Distinctive yellowing appears between the leaf veins; some plants show a broad band of discoloration on each side of the midrib. The plant is stunted and has short internodes.
   c. Iron—Leaves are pale yellow or white between leaf veins.
   d. Manganese—Leaves are yellowish gray or reddish gray with green veins.
   e. Copper—Young leaves are pale yellow and/or are wilted or withered; seedheads may not form.
   f. Chlorine—Upper leaves wilt then yellow.
   g. Molybdenum—Young leaves wilt and die along the margins; older leaves yellow due to their inhibited ability to utilize N.
4. Nickel—The Exception

   Deficiency symptoms have not been observed in field conditions, only in research settings, but include yellowing of young leaves and death of meristem tissue.

X. Mulches

Mulch is any material, organic or inorganic, that is spread upon the surface of the soil to protect it and plant roots from the impact of raindrops, crusting, freezing, and evaporation.

A. Organic Mulches

Organic mulches include grass clippings,

hay, straw, bark, sawdust, wood shavings, leaves, and newspapers. You can use almost any plant material for mulching as long as it allows air and water to penetrate to the soil below. Coarse-textured material, such as coarse-textured hay, straw, wood shavings, and chips, are more desirable than fine textured materials such as leaves, pine needles, and sawdust. When using fine materials, loosen them occasionally to keep them from sealing the soil surface.

B. Inorganic Mulches

Inorganic mulches include plastic films, mat-type weed barriers, aluminum foil, and even old carpet. Although inorganic mulches provide some of the same benefits as organic mulches, they cannot be incorporated into the soil at the end of the growing season and must be removed where you plant annual crops. Perforated plastic film or spun-bound material, such as landscape cloth, allows water and air to easily reach the soil.

C. Seasonal Mulches

A thin layer of mulch will conserve soil moisture, and 2 or more inches of mulch will control most weeds. Mulch effectiveness depends upon the material you are using and the weed species to be controlled.

1. Summer Mulches—Use summer mulches to control weeds, reduce water evaporation from the soil, stabilize water temperature, and reduce fruit rot on bare soil. Incorporate organic summer mulches in the fall to improve soil structure.
2. Winter Mulches—Use winter mulches to reduce water loss from evergreen plant tissue and to stabilize soil temperatures. Stable soil temperatures will minimize soil heaving caused by alternate freezing and thawing. Winter mulch applied too early in the fall can cause more winter injury than none at all.

D. Problems with Mulches

Organic mulches, such as cereal grain straw, can introduce weed seeds. The mulch may attract rodents, insects, and other pests as an overwintering site. Mulching too soon in the spring can prolong cool soil temperatures, which will delay the growth of warm-season crops. Material with a high C:N ratio such as bark, wood shavings, sawdust, or straw may temporarily reduce soil nitrogen available to plants unless you incorporate additional nitrogen fertilizer into the soil.

XI. General Information on Fertilizers

Fertilizer is defined as any substance added to the soil, or sprayed on plants as a foliar fertilizer, to supply one or more plant nutrients. Every mixed fertilizer or individual material sold has a guaranteed analysis written on the bag. The analysis gives the amounts of available nitrogen (N), available phosphate (P_2O_5), and soluble potash (K_2O), in that order. The three numbers are always percentages by weight. Certain secondary macronutrients and micronutrients may also be included in the analysis.

Many brands and formulas of fertilizer are on the market. Select a brand that supplies nitrogen (N), phosphate (P_2O_5), and potash (K_2O) in approximately the same ratio your soil test indicates. For example, if your test indicates you should use 1 pound of nitrogen (N), 2 pounds of phosphate (P_2O_5), and 1 pound of potash (K_2O), the ratio indicated is 1-2-1. You could use a 10-20-10, a 5-10-5, a 6-10-4, or an 8-17-7 analysis fertilizer. All of these are in approximate 1-2-1 ratios.

XII. Fertilizer Terminology

- Mixed fertilizer—A fertilizer that contains two or more of the macronutrients (N, P, K).
- Complete fertilizer—A fertilizer that contains all three macronutrients (N, P, K).
- Incomplete fertilizer—A fertilizer that is missing one, or more, of the major components found in a complete fertilizer.
- Grade—The guaranteed minimum analysis, in percent, of plant nutrients in a fertilizer, expressed as total N, available P_2O_5, and soluble K_2O.
- Chelates—The word chelate comes from the Greek word for "claw." Chelates are organic substances, or chemicals, that act like claws and help hold metal ions in solution, in an available form, so that plants can absorb them. The solubility of metals, particularly Cu, Fe, Mn, and Zn, is greatly increased when they are held by chelating agents.
- Soil amendment—A substance added to the soil

to change its pH or physical properties. A common example is the use of lime to increase soil pH.

XIII. Nutrient Sources and Fertilizer Types

Common nutrient sources and contents of fertilizers appear in table 3.

Table 3. Common sources and nutrient contents of fertilizers.

Nutrient and source	Nutrient content of fertilizer (% by weight)
Nitrogen (N)	
Anhydrous ammonia (gas)	82
Ammonium nitrate	33-34
Ammonium sulfate (24% sulfur)	21
Urea	46
Urea-ammonium nitrate solution (UAN)	28-32
Sulfur coated urea (slow release)	39
Monoammonium phosphate (MAP)	10-11
Diammonium phosphate (DAP)	18
Potassium nitrate	13
Calcium nitrate	15
Phosphorus (P_2O_5) [1]	
Normal or single superphospate (NSP or SSP)	20
Concentrated (CSP) or triple superphosphate (TSP)	46
Monoammonium phosphate (MAP)	48-55
Diammonium phosphate (DAP)	46
Ammonium polyphosphates (APP)	40-70
Potassium (K_2O) [2]	
Potassium chloride	60-62
Potassium sulfate (SOP)	50
Potassium nitrate	44
Sulfate of potash-magnesia (Sul-Po-Mag or K-Mag)	22
Calcium (Ca)	
Calcitic limestone	32
Dolomitic limestone	22
Gypsum	22
Burned lime	60
Magnesium (Mg)	
Dolomitic limestone	3-12
Magnesium oxide (magnesia)	55-60
Magnesium sulfate	9-20
Potassium-magnesium sulfate	11

Table 3. Common sources and nutrient contents of fertilizers (*continued*).

Nutrient and source	Nutrient content of fertilizer (% by weight)
Sulfur (S) [3]	
Ammonium sulfate	24
Potassium sulfate	18
Gypsum	12-18
Magnesium sulfate	14
Boron	
Borax	11
Boric acid	17
Chlorine (Cl)	
Potassium chloride	47
Copper (Cu)	
Copper sulfate	22
Copper ammonium phosphate	30
Iron (Fe)	
Iron sulfate	19-23
Iron chelate	5-14
Manganese (Mn)	
Manganese sulfate	26-28
Manganese chelate	12
Molybdenum (Mo)	
Ammonium molybdate	54
Molybdic acid	47
Nickel (Ni)	
NA	
Zinc (Zn)	
Zinc sulfate	23-36
Zinc chelate	9-14

[1] Rock phosphate is the basic material used in all P fertilizer production. Phosphate for use in fertilizers is either acid treated or thermal processed. Acid treatment is the most important and utilizes sulfuric and phosphoric acids.

[2] Elemental K is not found in nature due to its chemical reactivity. Potash (K_2O) is the primary source of potassium for fertilizer use. Potash is found beneath the surface in salt beds or in the brine of salt lakes and seas. Many minerals contain potassium, but the most important are sylvinite (20-30% K_2O) and langbeinite (23% K_2O).

[3] The primary source of S is soil organic matter.

XIV. Fertilizer Application and Timing

A. Fertilizer Timing

The timing of fertilizer application depends somewhat on the type of fertilizer and the plant being fertilized. In addition, soil texture determines application frequency and the amounts to apply. For soils with high sand content, the recommended fertilizer application may need to be divided into smaller quantities applied more frequently. The opposite is true for soils with high clay content.

As a general rule, the best time to apply any nutrient is close to the time the plant is growing the most and needs the nutrients. This prevents environmental losses and the nutrient's becoming unavailable in the soil before the plants can use it. It is best to apply foliar fertilizers when the weather is cool, but not cold, and when there is adequate soil moisture.

Phosphorus, potassium, and lime can be applied in the fall or as part of a tillage operation. It is important to apply nitrogen early in the spring during the active growth period. If your plants need a lot of nitrogen, it is best not to apply it all at once but rather to split the application into smaller amounts at two or three intervals. Some forms of nitrogen are very soluble and do not stay in the rooting zone very long. As a general rule, apply no more than 50 to 75 lb/acre of nitrogen in one application. Plants are more likely to utilize nitrogen applied in smaller amounts more frequently, and our groundwater and streams will be protected from nitrate pollution.

B. Fertilizer Application

There are several methods for applying fertilizers. The most common is to broadcast granular formulations on the surface or till them into the seedbed. Another method is banding— placing the fertilizer below the surface in a band below or beside a seed at planting time. Some fertilizers can be applied through an irrigation system. Fertilizers can also be applied in liquid or powder form. Micronutrients are usually most effectively applied as foliar sprays.

C. Salt Accumulation and Soil Leaching

Fertilizer is more likely to burn a plant in hot, dry conditions when the plant is stressed. If there is insufficient moisture after fertilizer application, then the salt concentration can increase, making it even harder for plants to take up water. Adequate water will help prevent high salt accumulations.

Potted plants should be leached every 4 to 6 months and garden soils at least once a year. Leach the soil by saturating it with water and letting it drain completely. A rule of thumb is to apply water in an amount that is double the volume of the pot. For instance, a 6-inch pot will hold about 10 cups of water, so use 20 cups of water to leach out accumulated salts. Different plants have different levels of tolerance for salt accumulation.

XV. Green Manure and Cover Crops

By definition, green manure crops are grown and incorporated into the soil to improve the soil. Cover crops are grown primarily to reduce soil erosion and nutrient leaching.

Usually, green manure crops are annuals and cover crops are perennials, either legumes or grasses. Cover crops can be incorporated into the soil and used as green manure crops.

When managed properly, both green manure and cover crops add nitrogen to the soil for use by the crops planted later. They tend to increase the level of soil fertility and soil humus. They improve the soil's physical properties of aggregation, porosity, bulk density, and permeability. Their effects are more pronounced in clay soil than in sandy soil.

A. Green Manure

The benefit of using green manure crops depends on the soil, climate, and species of plants grown. Environmental conditions that affect microbial growth determine the rate of decay of organic residues. Warm soil, proper aeration, and ample soil moisture increase microbial activity, thereby increasing the rate of decomposition of organic matter. Decomposition releases carbon dioxide and weak acids that help release nutrients. The chemical composition of the plants affects their value as a green manure crop.

Green manure crops have little influence on soil organic matter content if cultivation is continuous. In cooler climates, green manure crops can increase soil organic matter and nitrogen. In warmer climates, cultivation speeds up the rate of decomposition so an increase in soil organic matter content is difficult to achieve. Using green manure crops can improve soil structure, which enhances aggregation, and increase the space between soil particles.

Any fast-growing annual crop is a good choice for a green manure crop, such as ryegrass, wheat, barley, vetch, or field peas. A legume is a great choice because of its ability to fix nitrogen. Green manure crops should be seeded immediately following the harvest of the main crop and not allowed to go to seed. Incorporate them at least 2 weeks before planting the next crop. As grasses and cereal grains reach maturity they can tie up nitrogen, so they should be incorporated into the soil early in the growing season.

B. Cover Crops

Use cover crops for alleyways in orchards and vineyards to prevent weed growth and in gardens for pathways. Cover crops may require some maintenance such as mowing and fertilization. Cover crops are good for fall gardens in between the rows and in any other cleared areas.

Cover crops provide organic matter and store nutrients, which helps reduce nutrient losses from the soil profile by leaching of nitrogen, potassium, and other nutrients. Legumes add nitrogen to the soil and reduce erosion because they are deep rooted. Leaching is more of a problem on soils with high sand content.

A good ground cover reduces soil erosion by reducing raindrop impact on soil particles. Plant cover increases the water infiltration rate and minimizes water runoff. Leaves and stems "catch" the rain, and roots create channels for water movement in the soil.

Negative aspects of cover crops include competing with the main crop for nutrients and moisture and encroaching on the main crop. Cover crops may also provide a safe haven for gophers, mice, insects, and diseases that can attack the main crop.

XVI. Organic Fertilizers

Research has found no difference in the nutrient contents of organic food and regularly produced food. However, organic foods are less likely to have chemical residues. As far as the plant is concerned, it does not matter if nutrients are supplied by decaying plant material or from commercial fertilizers: nitrogen is nitrogen is nitrogen. Plants are self-contained biochemical factories, and all they need are raw materials (nutrients).

Generally, organic fertilizers release nutrients slowly. Organic fertilizers depend on microorganisms to break them down in order to release their nutrients. Therefore, most are effective only when soil moisture and temperature are suitable for microorganisms to be active. Some examples of organic fertilizer sources are listed below:

- Cottonseed meal—Approximate analysis: 7-3-2. It can be somewhat acidic so it is often used to fertilize acid-loving plants.
- Blood meal—Dried, powdered blood collected from slaughter houses is a rich source of nitrogen and may contribute some trace elements, including iron. Issues associated with animal byproducts used in food sources may be a concern.
- Fish emulsion—A partially decomposed blend of finely pulverized fish, it is high in nitrogen, a source of some trace elements, and has a strong odor.
- Manure—Nutrient content is generally low and varies with animal source and feed. Manures are best used as soil conditioners rather than as sources of nutrients. Fresh manure can damage young plant material due to its high mineral salt content if irrigation is not managed properly.
- Sewage sludge—A byproduct of municipal sewage treatment plants, it generally comes in two forms, activated and composted. Activated sludge has a higher nutrient content (approximately 6-3-0) than composted sludge (approximately 1-2-0). There is some concern that long-term use could lead to the buildup of certain heavy metals. Another concern focuses on its use in a garden around edible plants. The origin of the sludge determines its nutrient and

heavy metal contents. A sludge-based nutrient source should be analyzed for heavy metals before use.

Further Reading and Resources

Books

Minnich, J., and M. Hunt. 1979. *Rodale Guide to Composting*. Rodale Press, Emmanus, PA.

Soil Improvement Committee, California Fertilizer Association. 1997. *Western Fertilizer Handbook: Second Horticulture Edition*. Prentice Hall.

Havlin, J.L, J.D. Beaton, S.L. Tisdale, and W.L. Nelson. 1999. *Soil Fertility and Fertilizers: An Introduction to Nutrient Management*, 6th Ed. Prentice Hall, Englewood Cliffs, NJ.

Booklets and Pamphlets

University of Idaho

CIS 863	Fertilizer Primer
CIS 787	Liming Materials
CIS 815	Northern Idaho Fertilizer Guide: Blueberries, Raspberries, & Strawberries
CIS 853	North Idaho Fertilizer Guide: Grass Pastures
CIS 911	Northern Idaho Fertilizer Guide: Northern Idaho Lawns
BUL 704	Soil Sampling

Videos

How Water Moves Through Soil. University of Arizona. Available for check-out from the Benewah County Extension Office, St. Maries, ID.

Soil Monolith Collecting and Preserving. 1987. Available from the UI Soil and Land Resources Division, College of Agricultural and Life Sciences, Moscow, ID.

Web Sites

Natural Resources Conservation Service. Published Soil Surveys for Idaho. http://soils.usda.gov/survey/printed_surveys/state.asp?state=Idaho&abbr=ID

Idaho State Department of Agriculture http://www.agri.state.id.us

Potash & Phosphate Institute. http://www.ppi-ppic.org

Smithsonian Soils Exhibit. http://www.soils.org/smithsonian/

University of Idaho Master Gardener Program. http://www.ag.uidaho.edu/mg/

University of Idaho Pedology Laboratory. http://soils.ag.uidaho.edu/pedology/

Instructor Resources

Soil Texture Kits. Nine 2-lb texture samples can be purchased from the UI Soil Evaluation Team, Moscow, ID, (208) 885-7554. ($75.00)

Suggested Activities for Chapter 4, Soils and Fertilizers. Online at www.ag.uidaho.edu/mg/handbook.htm.

Published 1993. Revised 2008.

Chapter 6

HORTICULTURAL EQUIPMENT MANAGEMENT

IDAHO MASTER GARDENER
UNIVERSITY OF IDAHO EXTENSION

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Chapter 6
Horticultural Equipment Management

George F. Gardner, Former Extension Educator, Bannock County, Pocatello

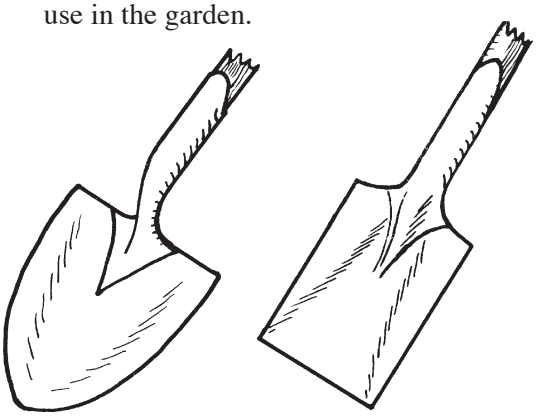
I. Equipment Selection

The type of equipment used to prepare your garden will depend on the size of the garden, as well as your physical ability, time, and budget. Options include a spade or shovel, a power rotary tiller, a small garden tractor, or a full-sized farm tractor.

A. Hand Tools for Cultivating

The minimum equipment needed by most gardeners is a shovel or spade, a hoe, a rake, and a trowel. A wide selection of styles is available. The right choice is one of personal preference and price. You can get the best value by knowing each tool's uses and particular qualities.

1. Shovel—A dish-shaped blade mounted to the handle at an angle and is used for moving soil. A garden shovel with a pointed blade is lighter and smaller than most other shovels and is well suited for use in the garden.

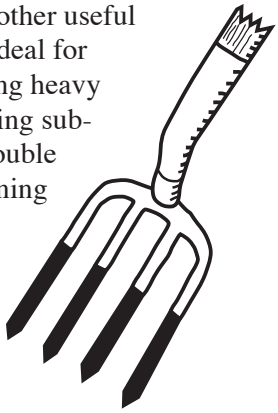


Shovel Spade

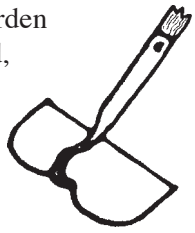
2. Spade—A flat blade and designed for cutting rather than lifting or moving soil. A spade is an excellent tool for shaping straight-sided trenches and edging beds.

Note: Shovels and spades come with long handles in standard or D-shaped styles. Choice of handle style will depend on personal preference: long handles offer greater leverage and are less tiring to use; short handles are often thicker and stronger. For general purpose digging, lifting, and moving, a long-handled shovel is ideal.

3. Spading fork—Another useful digging tool. It is ideal for breaking and turning heavy soil and for loosening subsoil layers when double digging a bed. Turning coarse compost, spreading mulches, and digging root crops are other jobs suitable for a spading fork.



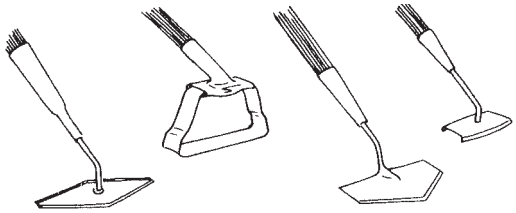
4. Hoe—Essential in any garden for preparing the seed bed, removing weeds, and breaking up encrusted soil. Several different hoe styles are available.



5. Pointed hoe—Has a heart-shaped blade and is lightweight and useful for opening seed furrows and cultivating between plants.
6. Hula—Or action hoe, is very lightweight and maneuverable. It is pushed and pulled just under the soil surface. Because the blade is relatively thin and lacks the clod-breaking capabilities of a heavier hoe, this type of hoe is most eas-

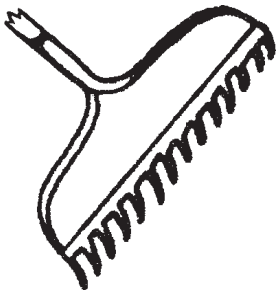
ily used where soil is not compacted and where weeds have not gotten started.

7. Scuffle hoe—Is somewhat more sturdy, and is used with a pushing motion rather than a pushing and pulling motion.

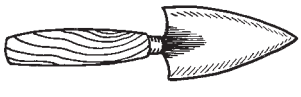


Different kinds of scuffle hoes

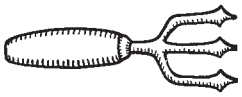
8. Square-bladed hoe—Probably the most commonly used hoe, lends itself well to many garden tasks.
9. Rake—Useful in clearing the garden of rocks and debris. It is also helpful in spreading mulches and smoothing seedbeds. The right rake depends on your size and strength and the uses you intend. As the number of tines increases, the rake weight also increases. Avoid choosing a rake that is so heavy it will tire you after a short period of use. The length of the rake handle is important too. The tip of the handle should come up to your ear when you stand upright. A handle that is too short will make your work harder, causing excess bending and back strain.



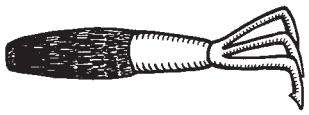
10. Trowel—Used for many digging jobs that do not require a full-sized tool. Especially in the spring, a trowel is perfect for transplanting seedlings and bulbs or digging shallow-rooted weeds.
11. Small hand cultivator—Often sold in sets with trowels, is useful for weeding small areas and between closely-spaced plants.
12. Digger—Also called a weeder, cultivator, or asparagus knife, is a small, useful digging tool. It is indispensable for digging up weeds with long taproots, such as dandelions or Queen Anne's lace; or for prying out Johnson grass rhizomes. It consists of a 10- to 14-inch long solid metal rod with a two-pronged blade at one end and a handle at the other. This tool is practically indestructible and well worth its price.



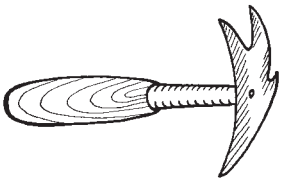
Transplant trowel



Small digging fork



Hand cutlivator



Planting—Cultivating hoe

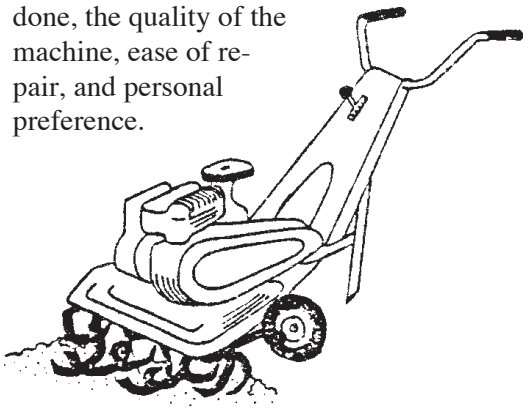


Dandelion digger or asparagus cutter

13. Pickax—Used to break up extremely stony or hard-packed soil.
14. Mattock—Used to break up soil, but is equipped with a cutting blade for removing large roots. A mattock may also be used to chop up debris for composting.
15. Wheel cultivator—Has a number of attachments for soil preparation and weed control and may prove to be a good investment for those with larger gardens.

B. Power Tools for Cultivation

1. Rototiller—The power rotary tiller is the tool most commonly purchased by gardeners. Whether you need a rototiller depends on the size of your garden, your capabilities, and the intended uses of the tiller. Tiller selection may be based on the nature of the work to be done, the quality of the machine, ease of repair, and personal preference.



The tiller's engine powers rotating blades, or tines, which turn the soil and makes it loose, fluffy, and ready for planting. It can also chop plant debris and mix it into the soil. The ability of the tiller to do these jobs effectively is a function of its weight, strength, design, type of tines, and type of soil.

A heavy, powerful tiller is most effective on stony clay soils, while a smaller tiller is more appropriate in a small garden or a garden with light soil. Very lightweight tillers, known as soil blenders, are designed mainly for raised bed gardening; however, they are not widely available and generally must be mail-ordered. A tiller is a major investment.

Look for tiller features such as: heavy cast iron, steel plate, and tubing; heavy bearings; strong welds used during construction; and easily operable controls. Ask to look at the operator's manual and try to determine how simply a tune-up can be performed. You can save yourself a great deal of trouble and money if you can replace plugs and points yourself. Also consider the locations of service centers and parts dealers. Careful attention to your needs, abilities, and price range is important.

Talk to people who have the types of tillers that interest you. If possible, borrow or rent various types of tillers and send for information before buying. If you are considering the purchase of a used rototiller, plan to do so well ahead of time so you will not be rushed into a purchase. If you know little about tillers, have a mechanically-minded friend evaluate the models you are considering.

Above all, test each tiller for ease of starting and operation. An engine that smokes or runs roughly may require a lot of work. Tines should operate smoothly and freely. Check the welds in the handles to see that they are strong; rewelding may mean that the handles have broken at some time, a common problem in older tillers. Look at the dipstick if there is one; low oil or very sludgy oil may mean that the tiller has been poorly maintained. The oil and other fluids may also be checked by opening the drain plugs. Look for excessive dirt around the engine or in the air filter. This may also indicate bad maintenance habits.

   a. *Rear-tine tiller*—If gardening is a full-time business or if you have a large garden, it would be wise to purchase a rear-tine tiller. It should be a heavy-duty machine capable of continued operation. The rear-tine tiller is easier to control and is smoother in its cultivating process. It requires less maintenance because it doesn't bounce around; leverage is required for control. New gardeners are sometimes scared away from these tillers because they can run away with them.
   b. *Front-tine tiller*—If gardening is simply a hobby, or if your garden is small, a front-tine tiller may be suitable. Front-tine tillers are usually light in weight, but may require considerable strength to guide them through the soil. Operating this type of tiller is comparable to handling a large floor polisher such as those used in schools and hospitals. Leverage is required for control. New gardeners are sometimes afraid that these tillers will run away with them. The front-tine tiller may not make as straight a path as the heavier rear-tine type, but it is much easier to turn. The front-tine tiller is easy to use in small gardens and in corner areas.

3. Cordless tools—Most are rechargeable, come with various cultivating attachments, and can make garden chores more pleasurable. Cordless tools are especially useful to those with physical disabilities that limit strength.
4. Garden shredder—This tool is helpful for a large garden with a lot of plant wastes. Hand-operated shredders are slow but useful if wastes are in small quantities and are not too coarse. Gasoline shredders are quite expensive and may be disappointing to the gardener who wants to

chip branches and other large materials. Shredders are best used for shredding leaves, small branches, and other plant wastes. A chipper, on the other hand, will chip large branches and other coarse materials, but the cost ($1,000) is high.

C. Wheelbarrow or Cart

A wheelbarrow or cart is handy to have in and around the garden area. It should be easy to handle when full. Durable construction is well worth the cost to ensure a long, useful life. Be sure to choose the size appropriate for your physical abilities and garden needs.

A wheelbarrow generally requires more strength and control than do most garden carts, but many of the small carts generally available are made of relatively flimsy metal and, though inexpensive, are not particularly long-lasting or suitable for heavy items such as rocks.

Consider your needs. If you plan to haul only light straw, leaves, or sawdust, then a small cart is suitable. For heavier jobs, a wheelbarrow or cart is needed.

The newer garden cart models, especially ones with bicycle-type tires, are made of heavy plywood and metal and are well-balanced and easy to maneuver.

Note: These carts do, however, cost a lot (up to several hundred dollars) and a large storage space. Only serious gardeners, or those with other uses for these carts, find them economical. One alternative is to build your own from one of several plans available from gardening magazines or private companies.

D. Watering Equipment

Watering is one job that most gardeners must do at least occasionally. An adequate water supply may make a big difference in garden yields. Purchase of watering equipment depends upon available facilities, water supply, climate, and garden practices. Determine whether cultural practices such as mulching, close plant spacing, shading, or wide-bed planting will meet most of your extra water needs, then purchase watering gadgets accordingly.

1. Spigot—If there is no outdoor spigot near the garden, the expense of having one installed may be greater than the benefits gained, except in very drought-prone areas, or in the case of a gardener who is fully dependent on the season's produce.
2. Rain barrel or garden hose with a fan-type sprinkler—This simple watering equipment will suffice where rainfall is adequate, except occasionally in summer.
3. Water breaker—Useful for small seedlings.
4. Drip irrigation system—In areas where there are extended periods of hot weather without precipitation, the local water supply is likely to be short. Since overhead sprinklers waste water, a drip irrigation system may be in order. Drip irrigation puts water right at the roots and doesn't wet plant leaves, thus helping to prevent disease. Timers are available for automatic drip watering systems, but this type of system is relatively expensive and may be considered a nuisance by some gardeners because of maintenance and replacement requirements.
5. The soaker hose—Probably the least expensive and easiest water system to use. It is fibrous hose that allows water to seep out at a slow rate all along its length. There are also hoses with holes in them that do basically the same thing. A flow regulator usually has to be included with the system so that water can reach the end of the hose, yet not be sprayed out at full force. A special double-wall type irrigation hose has been developed that helps to maintain an even flow.
6. Emitter-type system—Best used for small raised bed or container gardens. With this sytem, short tubes, or emitters, come off a main water supply hose. Emitters put water right at the roots of the desired plants. This is generally the most expensive form of irrigation and most complex to set up.

E. Seedling and Planting Tools

Depending on the size of your garden and your physical abilities, you may want to consider a row seeder.

1. Seeders—With wheels make easy work of sowing long rows of corn, beans or other vegetables. Seeders are available that make a furrow, drop the seeds properly spaced, and close up the furrow. It is not worth the effort to set up a seeder for small areas. A hand-held seeder is probably a better choice for this type of work.
2. Broadcast seeders—Are available for sowing seeds such as rye or wheat for cover crop, but are generally not necessary for the average home gardener, because broadcasting is easily done by hand once you learn the proper technique.
3. Fluid-sowing kits—Contain presprouted seeds in a gel that prevents drying. These kits may be purchased, but fluid sowing devices may be made inexpensively.

F. Environmental Monitoring Equipment

Serious gardeners often invest in equipment that allows them to moniter the microclimate around the garden or indoors.

1. Rain gauge—An inexpensive device that helps you determine if enough rain has fallen for garden plants.
2. Maximum-mimimum thermometer—A costly, but often useful, device to measure soil temperature and internal temperature of a compost pile.
3. Light and watering meters—Can be purchased for indoor plant monitoring.

   Electronic water meters measure the conductivity of soil, but are often greatly influenced by fertilizers and other salt concentrations, resulting in a variable or inaccurate measurement of water availability. Tensiometers work well for measuring water content.

G. Trellises and Cages

For vining plants, these save space and keep fruits off the ground, reducing plant damage and minimizing the amount of stooping required for harvest. Look for heavy-duty materials and sturdy designs that will stand up to rain, wind, and drying. Wire should be heavy gauge and wood should be treated with nonphytotoxic (nontaxic to plants) materials or materials nontoxic to humans. Metal parts should be rust-proof or rust-resistant.

If you build your own trellises and cages, you may save a considerable amount of money and get better quality.

H. Harvesting Equipment

Varies depending on the size and type of garden, whether food is to be stored, and the way in which it is to be processed.

1. Baskets—Useful to most gardeners. Baskets may be purchased at garden or farm supply stores or sometimes may be scrounged from local grocery stores or fruit stands. Berry baskets for carrying small fruits, baskets with handles for carrying vegetables, and peck or bushel baskets for storing fruits and vegetables are all useful.
2. Fruit pole pickers—Useful and easy to use for tall fruit trees.
3. A sharp knife—For cutting vegetables off plants is handy and helps prevent plant damage.

II. Equipment Purchases and Maintenance

A. Equipment Purchases

When purchasing tools, buy for quality rather than quantity. Your tools will be in frequent use throughout the garden season. Cheap tools tend to break or dull easily and may end up making your job unnecessarily difficult and frustrating. Quality tools will last and tend to increase in value if well kept.

Tools should be lightweight for easy handling, but heavy enough to do the job properly. Metal parts should be of steel, which will stay sharp, will keep their shape, and will outlast softer metals. Consumers' magazines and garden publications frequently have articles explaining what to look for in tools and listing alternatives to local hardware stores, which often carry a single line of tools. Several excellent books featuring garden tools have been published and may be available at the library.

B. Equipment Maintenance

Keeping a tool clean and sharp will increase its usefulness and lengthen its life. Learn the techniques of sharpening each tool and practice them frequently. Professional gar-

deners often carry sharpening stones or files and sharpen their tools every hour or so while working.

Clean tools after each use. One effective method is to keep a five-gallon bucket filled with sand and used motor oil in the tool shed. At the end of the gardening day, remove clinging dirt from tools by plunging them into the oily sand several times. This will keep the tools cleaned and oiled, and will help prevent rusting.

Perhaps the most important step in tool care is to put tools in their proper place. Tools left in the garden will rust and break and can be a safety hazard. Some gardeners paint handles with a bright color to make their tools easy to spot.

III. Cultivation Practices

A. Types of Soil Cultivation

1. Plowing—It once was assumed gardens should be turned yearly with a moldboard plow, mostly for weed and pest control. While garden plowing is still a common practice, turning the soil over completely has been found to be detrimental in some cases. It can cause soil compaction, upset balances of microorganisms, and bury layers of coarse organic material below the influence of insects and microbes, which would otherwise cause the materials to decompose.
2. Chisel plowing—This does not have this disruptive effect, is one alternative, but it is limited to sandy or loamy soils. Many gardeners do not have chisel plows. In addition, gardeners in non-rural areas have trouble finding a person who will plow and disk a garden for a reasonable price.
3. Rototilling—Most home gardens' soil condition is sufficient, as long as plant debris is not excessive. Rotary tilling mixes rather than turns the upper layers of soil. One possible harmful effect of rototilling is the formation of a compaction layer just beyond the reach of the tines. Use of deep-rooted cover crops or double digging can help prevent or alleviate this problem.
4. Hand cultivation—By spading the soil deeply until it is loose and drains easily, prepares the soil.

B. Cultivation Time

Fall tillage has several advantages over the traditional spring plowing. It allows earlier spring planting, since the basic soil preparation is already done when spring arrives. Turning under large amounts of organic matter in fall is likely to result in better decomposition because autumn temperatures are higher than those in early spring, and the process has more time to take place. Insects, disease organisms, and perennial weeds may be reduced by killing or inactivating them through burial or exposure to harsh winter weather. The physical condition of heavy clay soils may be improved by the alternate freezing and thawing, which break up hard clods. Fall tilling alone is not recommended for hillside or steep garden plots since the soil is exposed all winter and is subject to erosion when spring rains come.

If a winter cover crop is grown to improve soil and to prevent erosion, the ground will have to be tilled in the fall to prepare the soil for seed and again in spring to turn under the green manure. A cover crop decreases erosion of the soil during the winter, adds organic material when it is incorporated in the spring, improves soil tilth and porosity, and adds valuable nutrients.

Spring tillage is better for sandy soils and those receiving shallow tilling. Generally, most gardens must be disked or rotary tilled in the spring to smooth the soil for planting.

C. Cultivation Requirements

Work the soil only when the conditions are right. Pick up a handful of soil and squeeze it. If the soil crumbles freely, it should be about right. Take samples at the surface and at a 2- to 3-inch depth at several locations in the garden plot. If the soil is powdery or in clumps, it may be excessively dry and difficult to work. If soil sticks to a shovel, or if the turned surface is shiny and smooth when spaded, it is still too wet. Working soil when excessively wet can destroy soil structure, which may take years to rebuild. Plowing with a tractor when soil is wet is espe-

cially damaging. It causes the formation of a compaction layer that will inhibit root growth. Soils with adequate humus levels generally make cultivation easier because of their improved structural qualities.

Just before planting, break up large clods of soil and rake the bed level. Small-seeded vegetables germinate best in smooth, fine-surfaced soil. Do not pulverize seedbed soil. This destroys the structure and promotes crusting and erosion problems.

Any addition to the soil that improves its physical or chemical condition is considerated a soil amendment. Many types of amendments are available to the home gardener.

Further Reading

University of Idaho Extension

PNW 320 Calibrating and Using a Backyard Sprayer

CIS 1054 Low Input Landscaping

CIS 1065 Improving Sprayer Accuracy: Simple Methods for Correct Calibration

CIS 858 Using Bark and Sawdust for Mulches, Soil Amendments, and Potting Mixes

EXT 726 Weed Control in the Home Garden

Published 1996.

Chapter 7

PLANT MANAGEMENT: CHOOSING, PLANTING, AND MAINTAINING PLANTS

IDAHO MASTER GARDENER
UNIVERSITY OF IDAHO EXTENSION

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Chapter 7
Plant Management: Choosing, Planting, and Maintaining Plants

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INTRODUCTION

Creating a productive and beautiful garden requires care at several stages. It is important to choose plants that will thrive in your climate, soil, and light conditions. Proper planting procedures are key to ensuring successful plant establishment. From the time of planting through maturity, the plant's water needs must be met through proper irrigation. This chapter discusses each of these topics.

PLANT SELECTION

When choosing a plant, consider both the limitations of the site and the intended purpose of the plant. Maintenance issues and plant disease problems often result from selecting the wrong plant for a location.

Begin by analyzing the site. A plant needs adequate space both above and below ground. Your garden must be in an appropriate climate zone (both for winter hardiness and summer heat), and the soil must have adequate structure, depth, drainage, pH, and fertility. Choosing a plant that has some resistance to diseases or pests prevalent in the area might also be beneficial.

To determine the best location for a plant, read the plant tag or seed packet. You can also research the plant online or in a garden book. These resources are useful for determining the winter hardiness and heat zones, light exposure, and water required by a plant. Choosing a plant whose requirements match your site will help ensure a healthier plant for years to come and will decrease maintenance, chemical, and labor costs.

Light requirement

Light requirements differ among plants. Plants described as requiring full sun typically need at least 6–10 hours of direct sun per day. Plants adapted to partial sun/partial shade need 3–4 hours of direct sun. Shade-loving plants do best where they receive less than 2 hours of direct sun in early morning or where sun is filtered through a tree canopy.

Light intensity may vary across your yard. The south and west sides of a house receive more intense light (and are warmer) than the east or north sides. For this reason, the south or west sides are generally good locations for a vegetable garden or pollinator flower garden. The north and east sides of a house offer more shade and moisture for shade-loving plants such as hostas. By locating plants in sites with proper light exposure, you can avoid the frustration of having to replace those that died from too much sun or shade.

Climate

Winter hardiness. The United States Department of Agriculture's (USDA) plant hardiness zone map will help you determine which perennial plants will winter over in your garden. The USDA zone map was first published in 1960 and was updated in 1990 and 2012. Each zone represents the average lowest winter temperature for an area; it does not reflect record cold temperatures. Average temperatures are based on the lowest minimum temperature recorded each year from 1976 through 2005.

According to the USDA zone map, hardiness zones in Idaho range from zone 3b to zone 7b. On the current map, most Idaho locations are half a

zone warmer than in previous versions. A current USDA hardiness zone map for Idaho can be found at http://planthardiness.ars.usda.gov/PHZMWeb/Default.aspx.

Hardiness zones are based on temperatures recorded for large areas, but small areas within a zone can vary significantly. These areas are called microclimates. Sun reflected from a wall or fence can increase the minimum winter temperature, while shade from a tree or on the north side of a building can decrease it. Temperatures in a valley generally are lower than those found on the side or top of a hill. Even dark mulch material can moderate soil temperature by 5–10°F during spring or fall, when plant roots and crowns are not fully dormant, thus increasing winter hardiness. Other factors that affect a plant's ability to withstand cold are plant health, age of the plant, plant dormancy, snow cover, late winter warming, and moisture levels in the plant (especially evergreens) prior to the onset of winter. For these reasons, the hardiness zone map should be used only as a guide.

Heat stress. Heat stress is defined as exposure to high temperatures for a long enough period of time to cause irreversible damage to a plant's physiological functions. Heat stress can be caused by high air or soil temperatures. Stress increases rapidly as air temperature rises above 85°F. Plants can be injured directly by heat, or indirectly when a high transpiration rate causes a water deficit. Transpiration rate depends on plant size, light intensity, temperature, humidity, and wind speed.

It is best to avoid planting heat-sensitive plants near sidewalks, driveways, or buildings that reflect light and heat. Rock mulches can also increase the soil temperature enough to damage heat-intolerant plants.

The American Horticultural Society (AHS) has created a plant heat zone map based on the number of days with temperatures above 86°F. Some plant labels now include the plant's heat zone tolerance. A current version of the AHS plant heat zone map can be found at http://www.ahs.org/gardening-resources/gardening-maps/heat-zone-map.

Growing season. Knowing the length of the growing season is important if you want to grow warm-season vegetables or collect seeds from annual plants. The growing season is the period between the last average spring frost date and the first average fall frost date. Because frost dates vary greatly from year to year, the length of the growing season in any given location will vary. In Idaho, the growing season ranges from 60–90 days in the central mountains to 150–160 days in the southern high desert region.



Figure 1. Season extension methods, such as a hoop house, protect crops from cold temperatures.

Late spring frosts can damage warm-season vegetables and fruits. Because cold air is heavier than warm air, it flows downhill to low-lying areas. Thus, a garden positioned at the top of a sloped yard may not experience as much frost damage as one at the bottom of the slope. In densely populated areas, closely spaced houses, solid fences, walls, and thick hedges can prevent free drainage of cool air, thus increasing frost damage.

The growing season can be lengthened by using hot beds, cold frames, frost cloths, high tunnels, and "reflector ovens" (figure 1). These structures protect crops from cold temperatures and inclement weather. For information on season extension structures, see chapter 24, "Houseplants."

Avoiding weeds and poisonous plants

Avoid purchasing invasive species, noxious weeds, or plants that are poisonous to animals and children. Weeds compete with garden and landscape plants for water, nutrients, and space. Without adequate weed control, a garden can become unproductive and a source of frustration instead of joy. Many weeds were brought to the United States as ornamental plants or were used as inexpensive packing material in shipping containers coming from other

countries. Plants that behave well in one region can become noxious weeds in another.

A noxious weed is defined by the State of Idaho as any plant having the potential to cause injury to public health, crops, livestock, land, or other property. The spread of noxious weeds and their damage to Idaho's agriculture can be reduced by proper identification and handling of certain plants. Before purchasing mail-order plants, exchanging seeds with friends from other regions, or bringing plant materials home from vacation, check Idaho's noxious weed list. See chapter 14, "Weeds," for more information on weeds and control methods.

Some common ornamental plants, such as myrtle spurge (*Euphorbia myrsinites*), can cause eye and skin irritation, while others can cause illness or death in children or pets. Teach children not to put any plant material in their mouth, unless you have intentionally introduced them to it. Various Extension publications list poisonous garden or landscape plants. The American Society for the Protection of Cruelty to Animals (ASPCA) keeps a database of plants known to be poisonous to cats, dogs, and horses.

SITE PREPARATION

Prepare the site for planting by removing rocks, weeds, and other debris. Preparation may include grading, tilling, amending the soil, and installing an irrigation system. Grading the soil allows water to drain away from your home or the crowns of plants. In a steeply sloped area, terracing is an option.

If the soil is compacted, turning the soil with a shovel or rototiller may help loosen the soil and increase aeration for better root growth. Amendments are often added at this time. Choose appropriate amendments, based on a recent soil test, your soil's structure, and plant requirements. Humus (composted organic matter) is a good amendment for most soils, as it increases soil fertility and improves soil structure. For more information, see chapter 5, "Soils and Fertilizers."

With heavy clay soil or a high water table, raised beds, mounds, or berms may be needed to improve drainage. In areas with a high water table, tile drains can also be installed.

PLANTING

Seeds

Starting vegetables, herbs, and annual flowers from seed is economical and can be fun and rewarding. For more information, see chapter 21, "Principles of Vegetable Culture," or University of Idaho publications.

Bareroot plants

Bareroot plants are dormant herbaceous or woody perennial plants that have been dug and stored without soil around their roots. The roots are usually wrapped in damp sphagnum moss, sawdust, or paper to keep them moist. Bareroot plants weigh less and are easier to ship than plants with soil. Flower bulbs, flowering ornamentals, strawberries, asparagus, caneberries, grapes, fruit trees, and some shrubs, vines, and shade trees are commonly sold as bareroot plants.

Bareroot plants must be planted as soon as possible, while they are still dormant. For this reason, they are usually sold and planted in early spring or late fall.

If you purchase a mail-ordered bareroot plant, check to make sure the plant is healthy when it arrives. Look for mold or mildew, and make sure the roots do not smell rotten. Roots, rhizomes, and bulbs should feel heavy for their size, not lightweight or dried out.

The roots of a bareroot plant must not be allowed to dry out before planting. If you must hold a plant for a day or two, keep the roots shaded and wrapped in plastic, wet paper, or moist sawdust. If you cannot plant for several days, place the plant in a container with potting soil and leave the container in a cool, shaded location. Another technique for holding bareroot material is called heeling in. This procedure consists of digging a trench large enough to accommodate the roots and burying them until you are ready to plant. Keep the roots cool and moist to avoid breaking dormancy.

Before planting, make sure the roots are moist. If you have any doubt, soak the roots overnight. Prune off broken roots.

Dig a hole large enough to accommodate the roots without bending or cutting them. Build a conical-shaped mound of soil in the bottom of the hole and spread the roots over the mound so that

they will grow down and outward. Adjust the plant so that the old soil line at the base of the trunk or crown is at ground level or slightly higher. On fruit trees, the graft union should be well above ground. If a stake is needed for stability, add it now. For information on staking trees, see chapter 18, "Woody Landscape Plants."

In most loamy soils, it is not necessary to amend the backfill. In heavy clay soils, you may want to add some humus to improve aeration and drainage. In very sandy soils, humus can improve the soil's nutrient- and water-holding capacity. Any amendment should not represent more than 25 percent of the backfill volume, so that the backfill does not vary greatly from the surrounding soil.

Fill the planting hole halfway with backfill, making sure to work it in and around the roots. Water to help remove voids. Let the water soak in, and then fill the remainder of the hole with soil. Finish by watering again. Do not keep newly planted bareroot materials too wet after planting, since they are dormant and require little water.

Balled-and-burlapped stock

Balled-and-burlapped (B&B) plant materials are trees or shrubs dug from the ground with a portion of their root system and soil intact. The root ball is wrapped in burlap and secured with twine. If the plant is held at the nursery for a long time, new roots may grow through the burlap. If the ball is very heavy, a metal basket may be added to protect it from breaking and for easier handling. Plants often sold as B&B stock include needled evergreens, rhododendrons, and azaleas, as well as many deciduous trees and shrubs.

B&B plants can be planted almost anytime the ground can be worked. Because of their limited root system, however, it is best to plant them in the spring or fall when it is cool and moist so they can establish rapidly. If B&B plants are planted in summer, they must be adequately watered to ensure that the roots do not dry out.

Careful handling of the root ball is very important. If it is cracked or broken, the plant most likely will die. Never drop the root ball on the ground. Always support the root ball on the bottom when moving the plant; do not lift only by the trunk, as doing so can stress the root ball and cause it to break from the trunk. Keep the root ball moist, shaded, and covered with soil or sawdust until you are ready to plant.

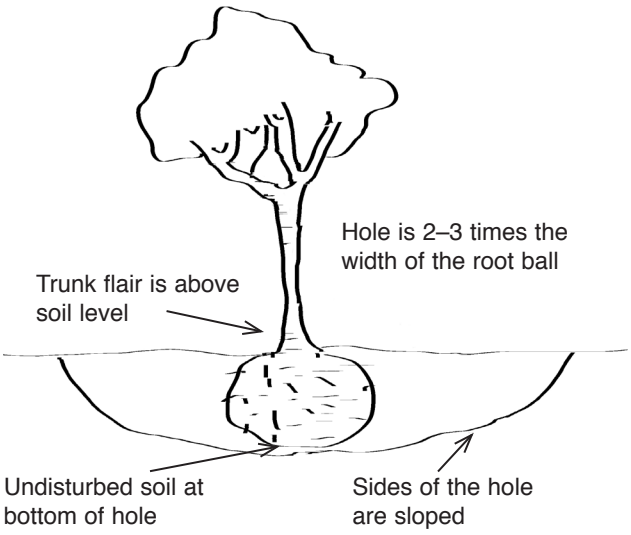


Figure 2. Planting hole size and configuration for balled-and-burlapped plants.

The size of the root ball determines the size of the planting hole. To prevent settling of the plant, dig the hole no deeper than the depth of the root ball. Make the hole at least two to three times wider than the width of the ball. Slant the sides of the hole outward so that the top is wider than the bottom (figure 2). This will allow water to enter the hole more easily and will provide space for the delicate roots to grow outward into the backfilled soil.

Place the root ball in the hole and half-fill the hole with soil. Water to settle the soil and remove voids. Next, untie the burlap from the trunk and lay it back on the soil, but do not remove it. Burlap should be removed only if it is *not* jute, but rather nylon or some other nondecomposable material. Fill the remainder of the hole with soil and then water again. If the burlap is not untied and buried, it will wick moisture from the root ball. For information on staking trees, see chapter 18, "Woody Landscape Plants."

Containerized stock

Most plant materials sold at nurseries and garden centers are in containers. Container-grown plants need the same careful planting as other plant materials. Their advantage is that they can be planted anytime the ground is workable.

The planting hole should be as deep as the soil in the pot and two to three times wider than the

container. Slant the sides outward. Remove the container, no matter what it is made of. The only exception is a small plant in a thin peat pot with roots growing through the pot. Even with peat pots, however, remove the top half of the pot to prevent wicking of soil moisture, and damage or remove the bottom of the pot to allow roots to escape. Thick paper or cardboard pots, sometimes erroneously called "peat" pots, should always be removed.

If roots are circling inside the pot or have taken on the shape of the pot, make four vertical knife cuts, one on each side of the root ball, to a depth of ¼ to ½ inch. Also make an "X" cut across the bottom of the root ball. If the roots are woody, use a hand clipper or sharp spade. New roots will grow from the cut roots.

Once cut, spread the roots slightly without breaking them, and place the plant in the hole. Fill the hole with backfill soil as described under "Balled-and-burlapped stock."

FERTILIZING

Plants need nutrients for proper growth and health. It is important to choose the proper fertilizer and method of application. For more information, see chapter 5, "Soils and Fertilizers," or the chapter that covers the relevant type of plant.

IRRIGATION

Adequate soil moisture is essential for plant growth and vigor. A healthy plant is 75–90 percent water. Plants need water to carry out vital functions such as photosynthesis, structural support, transpiration, and transport of nutrients and sugars. Poor irrigation practices can lead to problems such as iron chlorosis, wilting, leaf scorch, foliar diseases, root rots, and ground or surface water pollution. There is much to lose by not irrigating properly. Landscape plants can be expensive, and fully grown shade trees are impossible to replace.

Many gardeners underwater their plants by irrigating frequently for short periods of time. While a lawn can grow well enough with short, frequent irrigations, shrubs and trees do better with long, slow, infrequent irrigations.

Overwatering is as serious as underwatering. Roots require soil oxygen and can be damaged when excess water excludes oxygen from the soil profile. Excess irrigation also encourages root rots and other plant diseases.

Watering a landscape requires balancing the water needs of several types of plants. A typical suburban landscape includes an expansive lawn with a few mature trees. Flower and shrub beds may be located near the home's foundation or scattered around the lawn. There might be a vegetable garden in the back yard and a compacted path through the lawn leading to the back. There likely is a confusing mix of plants with varying drought and heat tolerances, such as pansies planted under junipers. Add a couple of planted containers on the front porch, and you have a typical suburban landscape that is challenging to irrigate.

Furthermore, moisture conditions vary throughout a landscape. A planted berm that continually loses water downhill will make the area below it overly wet. Areas shaded by mature trees likely will remain moist, but thickly matted tree roots inhibit grass growth. The north and east sides of a house are shaded and hold water longer than the south and west sides. Foundation plantings on the south and west sides of a house may need to be drip irrigated, as they will dry out quickly due to heat radiating off the house. Plants near a driveway or sidewalk face the same fate.

Factors affecting irrigation

Many variables affect the amount of water available to a plant. Soil type, slope, soil organic matter content, mulch, plant rooting depth, soil compaction, plant competition, evapotranspiration, and sprinkler efficiency all affect the availability of soil water.

Plant roots. The structure and growth habit of healthy plant roots strongly influence plant size and vigor. Since roots are out of sight, they often are misunderstood and their significance overlooked.

The depth and width of a root system depends on the growth characteristics of the plant, as well as on soil texture and structure. A root extracts most of its moisture from the top half of the root zone. This area is known as the effective root depth (figure 3). The effective root depth determines the amount of soil water accessible to the plant.

Newly emerged vegetable seedlings tend to have very shallow roots and must be irrigated frequently. Roots of most mature flowering perennials and

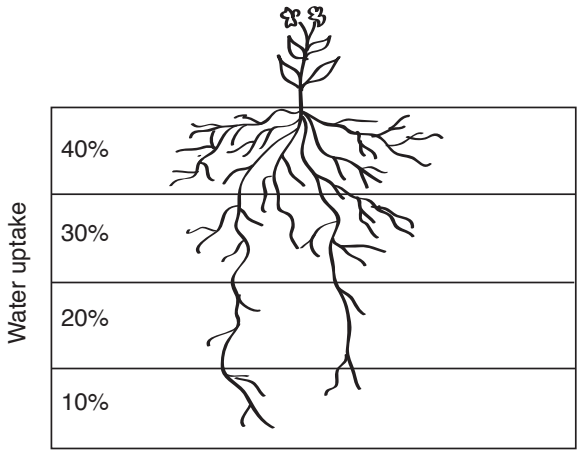


Figure 3. Effective root zone depth. Seventy percent of the moisture is extracted by the roots from the top half of the root zone.

vegetable plants exceed 24 inches in depth and width. See table 1 for effective root depths of common vegetables, fruits, and flowering plants.

On larger plants, it can be difficult to estimate the depth and width of the root system. Roots of deciduous trees growing in favorable conditions can spread two to three times the width of the canopy (branches). The horizontal root spread of evergreen trees is about twice the height of the tree. In both cases, the majority of the roots (the effective root depth) are in the top 2 feet of soil.

The rooting depth of turfgrass depends on the species. Kentucky bluegrass can have a rooting depth of 12 inches, while roots of turf-type tall fescue can be 4 to 6 feet deep! The effective root depth, where the turf obtains the majority of its water, is in the top half of the rooting zone. See chapter 15, "Turfgrass Establishment and Management," for more information.

In general, most plants need to have the soil thoroughly moistened around their roots with each watering. Allow enough time for the roots to extract most of the available water before irrigating again. See "Irrigation scheduling" and "Irrigating sections of the landscape" for information about determining how often and how much to water.

Evapotranspiration. Water moves to the atmosphere from the soil surface by evaporation and from plants by transpiration through plant stomata. Together, these processes are called evapotranspiration (ET), usually expressed as the depth of water (in inches) used in a specific period of time. Sunlight, temperature, relative humidity, wind, and

Table 1. Effective root depth in unrestricted soils.

Crop	Effective root depth (inches)
Vegetables	
Asparagus	36
Beets	18
Broccoli	18
Cabbage	18
Carrots	18
Cauliflower	18
Celery	12
Chives	6
Corn (sweet)	24
Cucumbers	18
Eggplant	18
Kale	18
Kohlrabi	18
Lettuce	6
Melons	24
Peas	18
Peppers	18
Potatoes	18
Pumpkins	24
Radish	6
Snap beans	18
Spinach	6
Squash	24
Swiss chard	12
Tomatoes	24
Turnips	18
Fruits	
Cane fruits	24
Grapes	36
Strawberries	6
Flowers	
Annual flowers	6
Bulbs, corms, rhizomes	12
Ground cover plant	6
Perennial flowers	18

the moisture level inside the plant affect the evapotranspiration rate. By providing an estimate of the amount of moisture used by a crop and lost through evaporation, ET rates indicate the amount of water that must be replaced with the next irrigation.

Daily ET values for crops and pastures are available from the AgriMet Weather Station Network, a service of the U.S. Department of the Interior Bureau of Reclamation. Unfortunately, these values do not accurately represent water use by biologically diverse plantings, such as those found in home landscapes or vegetable gardens. In general, ET rates often reach 0.3 inch or more in Idaho locations with hot summer days, low humidity, and high winds.

To reduce evaporation, water early in the morning if possible. Mulches (any material applied to the soil surface as a protective cover) improve water retention. They also reduce weeds and moderate soil temperatures. Organic mulches such as bark, wood chips, leaves, compost, grass clippings, and newspaper also improve soil structure and add some nutrients.

Inorganic mulches (solid plastic sheeting, woven nylon landscape fabrics, rocks, and gravel) retain moisture and reduce weed growth, but can have detrimental effects on plants. During hot, dry weather, rocks can absorb and reflect heat back to landscape plants and your home, making the area inhospitable for both plants and people. The weight of rocks also compacts the soil. Solid plastics do not allow oxygen or water to freely enter or leave the soil; these materials should be used only temporarily in vegetable gardens and never in a landscape. Both plastic sheeting and woven fabrics must be pinned down and covered with another mulch, such as wood chips, to prevent deterioration by ultraviolet light. Plastics and fabrics can migrate to the surface over time, even when secured with pins and covered with organic mulch, causing a landscape to look unsightly.

Water infiltration rate. Infiltration is the movement of water into the soil. The rate of infiltration is measured in inches or centimeters per hour. Clay soils have a slow infiltration rate, while sandy soils have a faster infiltration rate. For example, a sandy loam soil accepts ½–3 inches of water per hour, while a clay loam soil absorbs less than ½ inch of water per hour. If water is applied faster than the soil can accept it, either through precipitation or irrigation, the excess will pond or run off.

Compacted soils do not allow water to penetrate the soil surface. In a vegetable garden, tillage and organic matter additions will reduce compaction over time, but soils are very slow to change. Even with the addition of 1–2 inches of humus every year, it may be 4–5 years before any difference is noted in soil structure. Designated paths and planting beds will help prevent compaction in vegetable and flower gardens. For landscape beds, a 3- to 4-inch layer of organic mulch will reduce compaction by cushioning the soil from foot traffic and the pounding of water droplets.

In lawns, water infiltration can be reduced by compaction or a thick thatch layer. The best treatment for soil compaction in lawns is annual core aeration, followed by topdressing with ¼ inch of humus or good topsoil. Core aeration is usually done in spring or fall to reduce moisture loss around exposed turf roots.

Thatch is a spongy, brown layer made up primarily of dead grass stems and roots. Thatch production is a normal process for rhizomatous grass species, such as Kentucky bluegrass. To check for thatch, remove a section of turf, leaving the root system attached. The thatch layer is below the green grass blades but above the soil and roots.

A ½-inch-thick thatch layer is beneficial. Thicker thatch can harbor diseases and insects, and can interfere with water movement into the soil. Excessive thatch is often caused by overuse of nitrogen fertilizers, which causes grass to grow and die rapidly. Overwatering, poor drainage, and excessive use of fungicides or insecticides can also cause thatch buildup by harming the beneficial soil microbe populations responsible for decomposing thatch. A power rake or dethatcher is used to repair a lawn with an excessively thick thatch layer.

See chapter 15, “Turfgrass Establishment and Management,” for information about core aeration and thatch removal.

Permeability. The permeability rate of a soil is the speed at which water moves down through the soil profile. It is measured in inches or centimeters per hour. Soil compaction, plow pans, hard pans, clay layers, caliche layers, rocks, or changes in soil texture can influence permeability. A plow pan is a compacted soil layer created by tillage operations. A hard pan is an impervious layer, typically clay, that impairs drainage or plant growth. Caliche is a layer

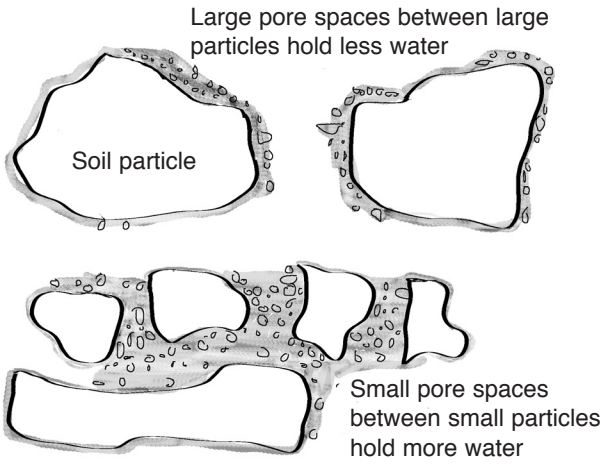


Figure 4. Pore spaces in soil. Soils with lots of large pore spaces, such as sand, hold less water than soils with small pore spaces, such as clay.

of lime (calcium carbonate) whose particles have been cemented together over time. A caliche layer can be so tightly cemented that roots and water cannot penetrate it.

Soil water-holding capacity. Soil stores moisture and supplies it to plants between precipitation events and irrigation. Water is held in pore spaces within the soil by capillary action and gravity.

The size and number of pore spaces is directly related to soil texture and organic matter content. A soil made up of large particles, such as sand, has a lower water-holding capacity than a soil composed of tiny particles, such as clay (figure 4). Regular addition of organic matter helps sandy soils hold water longer. Although clay can hold more water, the water is not necessarily available to plants because it takes more energy for plants to remove water from tiny pores.

See chapter 5, "Soils and Fertilizers," for more information about soil structure.

Soil texture interfaces. Soil texture interfaces occur where there is an abrupt change in the soil texture and the size of pore spaces. Water and oxygen can be very slow to cross an interface boundary.

Interfaces can occur naturally or be created by improper plowing, tilling, or planting methods. Amending the backfill during planting can create an interface by introducing a soil that is different from both the soil in the root ball and the native soil. All three soils will have different pore spaces, water-holding capacity, and water permeability.



Figure 5. Sprinkler overlap to provide head-to-head coverage.

A severe soil texture interface can inhibit root development and plant growth. Researchers at Washington State University's Research and Experiment Station in Puyallup, Washington, observed that when plants were transplanted into heavy clay soil, using a heavily amended backfill, roots began circling within the hole as though they were in a pot. The surrounding native soil did not have the same oxygen content, nutrient levels, drainage, or water-holding capacity as the amended backfill. For this reason, it is best to avoid amending the backfill when transplanting in most soils. Heavy clay soils or very sandy soils will benefit from some addition of humus, but do not change the backfill by more than 25 percent.

Sprinkler efficiency. Landscapes are typically watered by sprinklers. Sprinkler systems range from hose-end sprinklers to fully automated underground systems. The irrigation principles are the same for all types.

Hose-end sprinklers vary widely in application rate and spray pattern. Some apply more water near the sprinkler and less near the edge of the spray pattern. To ensure uniform coverage, overlap the spray patterns when moving a hose-end sprinkler. The middle of the new spray pattern should be on the outside edge of the previous spray pattern (figure 5). Oscillating fan-type sprinklers give more uniform coverage.

With underground sprinkler systems, the landscape is typically divided into zones. Sprinkler heads are arranged so that one sprinkler sprays all the way to the next, a configuration known as head-to-head coverage. Often, one area is included in two or more zones, especially near the middle of the lawn.

Regardless of the type of sprinkler system, check application rates and uniformity. On a windless day, place several straight-sided containers, such as soup or tuna cans, at regular intervals throughout the lawn. Run the irrigation system normally, not-

ing how long it runs. Measure the depth of water in each container to see how much water is applied during that period of time. Compare containers to see if a similar amount of water is applied to each area.

Irrigation scheduling

Irrigation scheduling involves planning when and how much to water. The goal is to maintain healthy plants without wasting water. Effective irrigation scheduling is possible only with regular monitoring of soil water availability and evapotranspiration. It is easy to think you are watering plants, but in reality you are making a water deposit into the soil.

When to water. Soil texture is an important factor in determining how frequently you should water. Although sandy soils allow quick, deep penetration of water, they tend to dry out more rapidly than clay soils and need more frequent irrigation. Heavy clay soils are more difficult to wet, but dry out much more slowly than sandy soils, allowing less frequent irrigation. Take the time to learn how long it takes for your soil to dry.

You can estimate soil moisture by feel and appearance. Obtain a soil sample to a depth of at least 1 foot, using a probe, auger, or shovel. Squeeze the sample firmly in your hand to form a ball. Soil that needs to be watered will be dry, and soil aggregates will separate easily. There will be no water staining on your fingers. In a clay soil, clods will be hard to crumble with applied pressure. Notice how the moisture at the surface compares to the moisture deeper in the soil profile. If the top is very moist but the soil is dry at 1 foot deep, increase the length of irrigations to allow moisture to travel down through the profile.

Resistance to the probe or shovel can be useful in gauging soil moisture content. If the probe enters the soil easily but stops abruptly after several inches, even with all of your weight on the handle, you may have reached dry soil or an impervious layer. Keep in mind, however, that compacted clay soil can be very difficult to probe even when moist, while a sandy soil can be easily probed even when dry.

Rocks or gravel will also stop the probe, but they are easily identified by a metallic sound when hit.

Soil moisture meters, available at nurseries and garden centers, are another method of checking soil moisture levels. These inexpensive meters are often inaccurate, however. If soil fertility is high, meters tend to overestimate soil moisture. If fertility is low, they underestimate moisture. You will need to learn how to interpret meter readings for your soil by trial and error.

Often, close observation of plants can help with irrigation scheduling. The level of drying a plant will tolerate depends on species and plant size. See "Irrigating sections of the landscape" for information relevant to specific plant types.

How much to water. Always water long enough to fill the entire root zone. In a typical garden or landscape, you must learn how long it takes to adequately moisten the root zones of various plants.

Because newly emerged vegetable seedlings have shallow roots, moistening just the top few inches of soil is often recommended. However, for a large shade tree with a root system the width of the yard or beyond, it can take hours to adequately water the entire root zone in clay soil. If the infiltration rate is low, some of this water is likely to run off rather than soaking into the soil. For this reason, some gardeners with clay soil "cycle water." This technique involves watering several times in one day, allowing the water to soak in between irrigations.

The easiest way to determine how long to water is to wait 12 hours after an irrigation and use a shovel or soil probe to dig or probe to a depth of 10–12 inches. Take a small handful of soil from the bottom of the hole or soil core and squeeze it. It should form a weak ball and feel slightly damp, like a wrung-out sponge. If the soil feels drier, water longer. If water drains freely from the soil when squeezed, reduce the length of irrigations. Check the soil moisture at this depth once a month in several areas of your yard.

For more information, see "Irrigating sections of the landscape."

Irrigating sections of the landscape

Lawns. Water lawns deeply but infrequently. Deep watering improves soil aeration, reduces water loss to evaporation, reduces weed populations, and produces a healthy lawn. Water long enough to wet the soil to a depth of approximately 1 foot. Often, irrigating once or twice a week in summer is sufficient, as long as the proper depth is reached.

The frequency of irrigation will change based on the weather, while the amount applied should

remain fairly constant. It always takes the same amount of water to fill a 1-foot depth, but the length of time it takes the lawn to use this water depends on the weather. Irrigate less frequently in the spring and fall than in the summer.

It is best to *not* wait for your lawn to show symptoms of drought stress before irrigating. Stress symptoms are a sign that you've stretched the irrigation interval too long. If the grass does not spring back when walked on, or it takes on a bluish-gray cast, it is past time to irrigate and you should water immediately. If healthy turf dries up and turns tan, it may indicate that cool-season grasses have gone dormant. If not left too long, the grass will green up again when it receives adequate moisture.

For more information, see chapter 15, "Turfgrass Establishment and Management."

Trees and shrubs. Whenever possible, avoid overhead watering of woody trees and shrubs. Frequent wetting of leaves provides an environment in which foliar diseases can thrive and increases water loss to evaporation.

The water requirements of trees and shrubs change as they grow and mature. Even a tree or shrub that is described as "drought tolerant" or "low water use" needs to be watered regularly until it is well established.

Mature trees and shrubs need to have water available from their trunks out to and beyond their drip line (the end of the branch tips; see figure 6). Root systems can easily extend beyond the drip line, so watering right next to the trunk does very little, especially for large trees.

If a tree or shrub is surrounded by lawn, the lawn's sprinkler system will supply some water. However, trees and shrubs need deeper, less frequent irrigation than lawns; otherwise, the roots will grow close to the surface and be subject to drought stress. Thus, occasional deep irrigation with a garden hose or soaker hose may be necessary. Water deeply every 1 or 2 weeks in summer. Soak the ground in several areas around and beyond the drip line. If using a garden hose, use a low flow rate and let the water soak in.

If the tree or shrub does not receive water from lawn irrigation, water with a garden hose or drip irrigation system. If using drip irrigation, place emitters around the drip line of the plant, not near the trunk. For more information, see chapter 18, "Woody Landscape Plants."

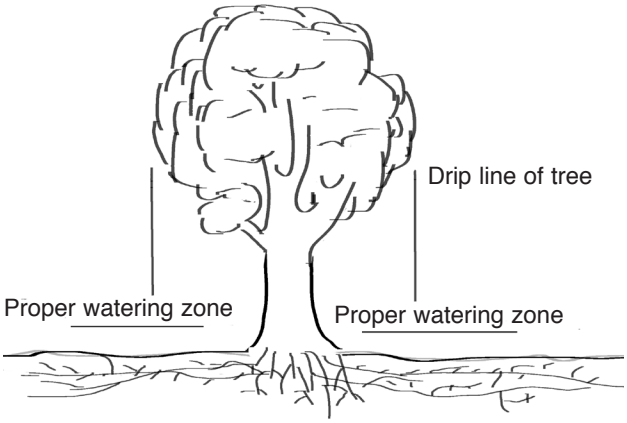


Figure 6. Proper watering area for a mature tree. The root systems of trees extend beyond their crowns.

Flowers and vegetables. In general, most flowers, small fruits, and vegetables require adequately moist soil all season long to produce their best. All of these plants differ in their water requirements, making irrigation a challenge. With inadequate water, lettuce and cucumbers can become bitter, and some flowers (such as peonies) may not bloom. On the other hand, tomatoes and irises may do fine with less frequent watering.

Gardens can be watered by gravity (flood), sprinkler, or drip irrigation. Gravity irrigation is not the most efficient method, but it fits well with a traditional vegetable garden consisting of long rows. Sprinkler irrigation is more efficient, but may increase the risk of foliar diseases. Sprinklers can be difficult to use with tall flowers or crops and with trellised plants. Drip irrigation is well suited to flower beds and vegetable gardens, as it applies water efficiently and keeps the leaves dry. Many types of drip tubing and emitters are available.

When using flood irrigation, make sure the water reaches the end of the row in a third of the time it takes to do a full irrigation (for example, within 10 minutes for a 30-minute irrigation). This ensures that the plants at the ends of the rows will receive enough water to reach into the lower depths of their root zones.

See chapter 19, "Principles of Vegetable Culture," chapter 23, "Small Fruits," and chapter 19, "Herbaceous Ornamentals," to learn more.

Containers. Plants in containers need more water than plants in the ground. Most potting soils dry rapidly. Also, the root zone in a container is limited, and roots are not well insulated from high temperatures. Outdoor container plants may need to be watered several times a day during warm, sunny periods. Check the soil moisture by probing the top inch of soil with your finger. If the soil is dry, it's time to water.

A drip irrigation system on a timer is a very effective way to keep containers adequately watered. However, containerized plants can be watered with a garden hose or watering can if watering is consistent throughout the summer.

Always irrigate several times or until water runs through the drainage holes in the bottom of the container. (Planting containers must have drainage holes for proper watering.) Don't be fooled, however, by a dry root ball that allows water to run around the edges of the pot and out the bottom without moistening the root ball.

Very dry root balls and soils with high peat content are especially difficult to rehydrate once they become dry. You may have to set the bottom of the container in a basin of water to remoisten the root ball or peat moss. Rehydration may take an hour or more, but do not leave a container sitting in water for more than 12 hours, as doing so may cause root damage due to lack of oxygen.

A good test to see whether the soil has taken up adequate moisture is to lift or tip the container. A well-watered container is much heavier than a dry one.

A pot that is too small for its plant will fill with roots, leaving little room for potting soil or water and causing the plant to dry out quickly. Transplant root-bound plants into larger containers.

Unglazed clay pots are porous and need to be watered more often than glazed or plastic pots. However, plastic pots offer poor root insulation. Adding a layer of thin Styrofoam sheeting on the inside of a pot prior to filling it with soil will improve insulation.

FURTHER READING AND RESOURCES

Penick, P. 2016. *The Water-Saving Garden: How to Grow a Gorgeous Garden with a Lot Less Water.* Ten Speed Press, Berkeley, CA.

Natural Resources Conservation Agency. 1998. *Estimating Soil Moisture by Feel and Appearance*. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_051845.pdf

Websites

American Horticultural Society. Plant Heat Zone Map
http://www.ahs.org/gardening-resources/gardening-maps/heat-zone-map

American Society for the Prevention of Cruelty to Animals. Toxic Plants List
http://www.aspca.org/pet-care/animal-poison-control/toxic-and-non-toxic-plants

USDA Natural Resources Conservation Service. Web Soil Survey
http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

USDA Plant Hardiness Zone Map
http://planthardiness.ars.usda.gov/PHZMWeb/Default.aspx

U.S. Department of the Interior Bureau of Reclamation, Pacific Northwest Region AgriMet
http://www.usbr.gov/pn/agrimet/

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Chapter 8
Backyard Composting

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I. Introduction

Composting is the biological decomposition of organic matter. We practice it to recycle unwanted organic materials, such as yard trimmings and food scraps, and to produce compost, a valuable soil amendment. Finished compost takes on many of the characteristics of humus, the organic fraction of soil. Like humus, compost improves garden soils and aids in plant growth.

While composting occurs naturally, human intervention can accelerate it. The quality of the compost and the production speed depend upon several factors that human composters can manipulate.

II. The Composting Process

A. Process Basics

Composting is an aerobic, or oxygen-requiring, process. The microorganisms and other biological decomposers responsible for composting consume oxygen along with the organic materials and produce primarily compost, carbon dioxide, water vapor, and heat (Fig. 1). The heat that is produced raises the temperature of the composting materials.

The oxygen consumed during the process must continually be replaced by air movement through the materials. Because the penetration of air may be inadequate or inconsistent, some decomposition inevitably occurs under anaerobic conditions (without oxygen). Anaerobic decomposition is slower than aerobic decomposition, produces little heat, and creates odorous byproducts. The challenge for the composter is to minimize anaerobic decomposition by creating and maintaining conditions that favor the desired decomposers.

B. Decomposers

Decomposers are the microorganisms and invertebrates that accomplish composting. Naturally occurring microorganisms, such as bacteria, fungi, and actinomycetes, account for most of the decomposition, as well as the rise in temperature that occurs in the compost process. Invertebrate animals, such as mites, millipedes, insects, sow bugs, earthworms, and snails, produce much of the physical decay where the temperature is relatively cool (below 90°F).

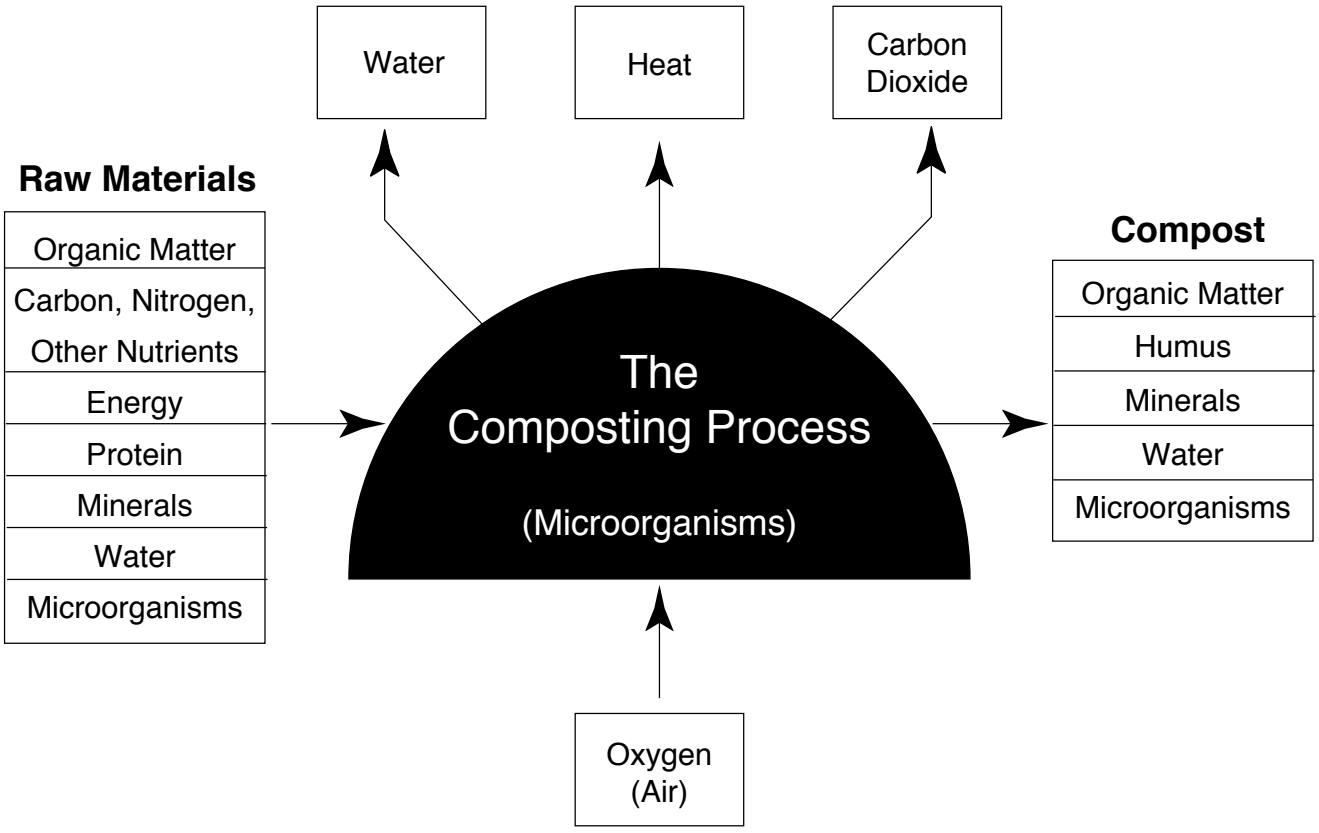
Different decomposers prefer different organic materials and environmental conditions. A diverse microbial population represents a healthy compost pile. If the environment becomes unsuitable for a particular decomposer, that organism will become dormant, die, or move to a more hospitable area of the pile. Changing conditions during the composting process lead to an ever-changing ecosystem of decomposer organisms.

1. Microorganisms: food and water.
   a. Bacteria are the workhorses of the compost pile. They are the most numerous and active decomposers. Bacteria generally prefer moist conditions and attack the easily decomposed materials such as green vegetation, food scraps, and manure.
   b. Actinomycetes (a branching type of bacteria) and fungi (yeast and molds) attack the more resistant materials that bacteria use less efficiently. Fungi are particularly good at decomposing woody materials. These groups of organism are also more tolerant of dry conditions than bacteria. They become more important near the

end of the process when the resistant organic compounds remain (e.g., cellulose and lignin compounds). The filaments, molds, and spores formed by fungi and actinomycetes are often visible in the later stages of composting.

2. Aerobic vs. anaerobic microorganisms.
   a. Aerobic organisms provide the most rapid and effective composting. They thrive at oxygen levels greater than 5 percent (fresh air is approximately 21 percent oxygen).
   b. Anaerobic bacteria prevail when oxygen is scarce. Anaerobic conditions are undesirable in a compost pile because the decomposition products are often odorous. For example, a common product of anaerobic decomposition is hydrogen sulfide that smells like rotten eggs. Other odorous anaerobic products, some with aptly descriptive names like "putrescine" or "cadaverine," are formed from organic nitrogen compounds.
3. Microorganisms and temperature—Microorganisms are grouped according to the temperatures in which they thrive.
   a. Psychrophilic organisms work in the lowest temperature range and have an optimum temperature of about 55°F. Mesophilic organisms thrive at temperatures between 70° and 100°F. Thermophilic organisms are heat-loving and operate in a range between 113° and 155°F. If the temperature rises above 140°F, even the thermophilic microorganisms begin to suffer and decomposition slows.
   b. Aerobic microorganisms are the most important initiators of decomposition and temperature rise within the compost pile. The initial temperature of the compost pile is usually near ambient air temperature. Psychrophilic bacteria typically begin the decomposition. Their activity generates a small amount of heat that increases pile temperature. This change in environment

Fig. 1. The composting process.



allows mesophilic organisms to dominate. In turn, the more rapid decomposition by mesophilic bacteria further increases the pile temperature and creates an environment for the thermophiles to thrive. Later, as the compost matures, temperature decreases, mesophilic bacteria again dominate, and finally psychrophiles and invertebrates return.

c. Although microorganisms are the primary decomposers in a compost pile, larger organisms also play a significant and beneficial role. Callemacroorganisms, invertebrates, or secondary decomposers, these organisms include nematodes, flat worms, earthworms, snails, slugs, mites, springtails, beetles, ants, fly larvae, grubs, centipedes, millipedes, and sow bugs. Macroorganisms feed on plant tissue, partially decomposed organic matter, or other organisms. In the process, they break particles into smaller pieces, mix and transport nutrients, convert materials into forms that microorganisms can digest, and add their own byproducts and cell tissue to the compost.
Macroorganisms are not tolerate of thermophilic temperatures. As temperatures rise above 90°F, they will die, become dormant, or escape to the soil or cooler sections of the pile. They will return after the temperature falls to tolerable levels.

C. Factors Affecting the Composting Process

1. Aeration—Rapid aerobic decomposition can only occur in the presence of sufficient oxygen. Aeration replaces the oxygen-deficient air fresh oxygen-rich air inside the compost pile. It also removes heat, water vapor, carbon dioxide, and other gaseous products of the composting process. Aeration occurs naturally by diffusion, wind, and when warm air (heated by the compost process) rises through the pile and draws in cool, fresh air from the surroundings.

   a. Porosity: The compost pile's porosity and moisture content affect air movement through the pile. Porosity is a measure of the spaces between particles within the compost pile. These spaces provide a path for air circulation. Porosity suffers as the composting material becomes wetter because the material in the pile becomes heavier and more compacted. Adding coarse materials, such as leaves, straw, or cornstalks, increases the pile's porosity, resists compaction, and promotes good aeration.

   b. Turning: As composting proceeds and the materials decompose, they shrink in size and begin to settle. Settling reduces the pile's air spaces and restricts aeration. Regular mixing of the pile, referred to as turning, reverses the effects of settling.
   Although turning recharges the pile with fresh air, its main effect is to fluff up the material. This increases the pile's porosity and improves natural air circulation. Turning also blends the composting materials and breaks apart clumps of materials. Because of these benefits, turning speeds the composting process.

2. Moisture—Microorganisms need moisture. Water serves as a medium for chemical reactions and provides a means for movement of nutrients and microorganisms. On the other hand, too much water makes the materials soggy and heavy, hindering aeration as explained above.

   a. Generally, a moisture content in the range of 40 to 60 percent provides adequate moisture without limiting aeration. In practice, the acceptable level of moisture depends on the materials that you are composting. Coarse or fluffy materials such as leaves or straw can be wetter than 60 percent moisture content and still aerate well. Absorbent materials may need to be well above 40 percent moisture to compost rapidly.

   b. The "squeeze" test is an easy way to gauge the moisture level of composting materials. The material should feel damp to the touch, but not dripping wet. Water should drip from the mate-

rial only when you squeeze it tightly in your hand. If you can't squeeze water out, the pile is too dry (see Section IV, Subsection H on "Moisture Management," page 7-12).

3. Carbon-to-nitrogen ratio (browns and greens)—Microbial decomposers obtain many nutrients from the composting materials but carbon (C) and nitrogen (N) are the nutrients that affect the process the most. Microorganisms primarily use carbon compounds as an energy source and ingest nitrogen for protein.
   a. Because they require a balance of both nutrients, the proportion of carbon to nitrogen is important when combining organic materials to make compost. The ideal ratio (C:N) of these two elements is about 30 parts carbon to 1 part nitrogen by weight. At this 30:1 ratio, microorganisms decompose organic material quickly. When the C:N ratio is higher, the shortage of nitrogen slows decomposition. When the C:N ratio is too low, excess nitrogen is lost to the atmosphere in the form of ammonia gas. In concentrated amounts, this can lead to odor problems. Generally, C:N ratios within the range of 20:1 to 50:1 yield good compost in a reasonable time without odor problems.
   b. Most composting materials, by themselves, do not contain C and N in the right ratio (Table 1). Still, you can achieve the desired C:N ratio by mixing several materials together in appropriate proportions. We refer to the materials used and their proportions as a "recipe."

Table 1. Typical carbon to nitrogen ratios of selected home composting materials.*

	Material	C:N ratio
BROWNS	Dry leaves	60:1
	Corn stalks	60:1
	Straw	80:1
	Shrub trimmings	50:1
	Waste paper	400:1
	Wood (sawdust, shavings, etc.)	500:1
GREENS	Grass clippings	17:1
	Kitchen scraps	15:1
	Vegetable culls	12:1
	Cattle manure	18:1

*These values are only approximations. The C:N ratio of any of these materials varies considerably from one source to the next and as the materials age.

Note: In a backyard or home composting situation, it is impractical for you to be precise when developing recipes. You can roughly predict the C:N ratios of mixtures from estimated C:N ratios of the ingredients as in Table 1. An easier approach is to develop recipes by thinking of carbon sources as "browns" and nitrogen sources as "greens" and then combining brown and green materials in rough proportions. For example, a mix of one to three volumes of browns (dry leaves) to one volume of greens (fresh grass clippings) often produces a C:N ratio in the 30:1 to 50:1 range.

4. Surface area and particle size—Most microbial activity occurs along particle surfaces, where oxygen is available from the adjacent air spaces. Because surface area increases as particle size decreases, chopping, shredding, or cutting material into smaller pieces usually speeds decomposition. There is a limit to this benefit. Smaller particles also decrease the pore size and structure and restricts aeration. Therefore, some compromise is necessary. Usually a mixture of particles in the range of 1/8 inch to 2 inches (in the largest dimension) gives good results.
5. Degradability—The nature of the materials largely determines the speed at which composting occurs. Not all organic materials decompose at the same rate.
   a. Overall, microorganisms easily digest materials made from sugars, starches, proteins, and fats such as food scraps, manure, and green vegetation. Typically, nitrogen-rich materials or "greens" are the first to decompose in the composting process.
   b. Materials such as straw and plant stems contain a large amount of cellulose that takes longer to decompose.

Woody materials contain a biologically resistant compound called lignin. Raw wood products, including sawdust, are particularly difficult to decompose biologically and pass through the composting process with little change. Paper, a wood derivative, decomposes relatively fast because of the processing it receives in the papermaking process. You can improve the degradability of a biologically-resistant material by reducing its particle size and ensuring that adequate amounts of nitrogen and water are available.

6. Temperature—Heat, generated by microorganisms, raises the temperature of the compost pile. Depending on the pile size, moisture content, and the material that you are composting, pile temperatures will rise temporarily to 100° to 120°F and may even surpass 160°F. Temperatures between 90° and 140°F promote rapid composting. Microbial activity decreases as the temperatures reach 140°F or higher. Many of the organisms die when temperatures exceed 160°F.
   a. Because microbial activity and the heat generated are related directly, temperature is a useful guide in understanding how well composting is progressing. Rising temperatures reflect increased microbial activity. Warm, steady temperatures indicate steady activity. Falling temperatures suggest that the compost microbial activity is decreasing, either because the compost is maturing or because a problem, such as lack of oxygen or moisture, exists. You can easily measure temperatures in your home compost pile with a dial thermometer with a 12-inch stem (available from garden stores and catalogs). You also can use the clues in Table 2 to judge the temperature level.
   b. Home composting piles tend to be small and are frequently short of nitrogen. Therefore, if high temperatures (above 120°F) are reached at all, they are usually sustained for only short periods of time. Piles typically get hot soon after adding a large load of green material, such as grass clippings, and then gradually cool. High temperatures have the advantage of killing pathogenic organisms and weed seeds. Moderate temperature also result in effective composting, however. It is not important to achieve high temperatures if the materials being composted are not diseased and do not contain many seeds.
7. Time—Depending on the composting method, materials, and conditions, it can take several weeks to several years to produce finished compost. Methods that involve little or no turning usually require more than a year to produce mature compost. With regular turning, adequate moisture, and a good mixture of carbon (brown) and nitrogen (green) materials, compost is ready for use in 3 to 4 months. With daily turnings and highly degradable material, you can reduce the composting time to less than a month. Frequent turning is of little benefit if you are using slow decomposing materials or if the C:N ratio is high (too many browns). These materials need time, more than oxygen, to decompose.

   Because an immature compost can cause damage to plants, it is best to be conservative in judging when composting is finished (see Section IV, Subsection K, "Judging When Composting Is Finished," page 7-12).

Table 2. Indirect clues of compost pile temperature level*.

Clue	Temperature level
Material is frozen beneath the surface	Frozen—little activity
Pile feels cold, colder than the surrounding air	Low—slow rate of composting
Pile feels warm, not hot	Moderate—rapid composting
Pile is steaming and hot to the touch	High—rapid composting
Pile is hot to the touch and the material inside of the pile looks or smells charred	Too high—undesirable

*These are rough guidelines. Actual conditions depend on factors such as pile size, materials, and composting stage.

III. Composting Methods

The container and the manner and frequency of turning characterize backyard composting methods. Common backyard methods include piles, bins, ventilated containers, and rotating barrels

A. Piles

1. A freestanding pile or heap is the simplest form of composting, and it works very well. You can add materials to the pile as they become available or stockpile until you have sufficient materials to make a good sized heap. In either case, it is helpful to have two or three piles—one for fresh material, another in the active composting stage, and possibly a third for maturing compost. To generate enough heat to raise the pile temperature, an actively composting pile should be 3 to 5 feet wide and at least 3 feet high. Larger piles retain heat better, but as piles grow in height they become more difficult to aerate.
2. You can turn piles regularly or not at all. A pitch fork is the typical turning device, although you can use other tools to loosen the pile. If the pile receives little or no turning, then add highly degradable materials only in moderation.

B. Bins and Ventilated Containers

Bins are managed in almost the same manner as piles. Compared to piles, bins more neatly contain the composting materials and allow you to stack them higher. Certain types of bins also discourage animal pests and keep rain away from the composting materials. See pages 7-16,17,18 for the wide variety of bins that you can use. They differ in cost, construction materials, ventilation, and ease of turning. Some bins are expensive or require effort to build while others need little assembly and may even be free.

Backyard composting bins are sometimes grouped into two basic categories: (1) holding units that let the materials decompose undisturbed, and (2) turning units that allow regular turning of the composting material. The distinction between holding and turning bins easily becomes blurred. Some structures typically used for turning often can serve as holding units and holding bins can be turned.

1. Holding bins—Generally made of light materials, holding bins are easy to take apart and move. Once the bin is apart, you can turn or harvest the finished compost. Common bin materials include circles of wire fencing or hardware cloth, old wooden pallets tied together, snow fencing, or wire mesh framed in wood. You can make stationary bins with wooden slats or by stacking together landscape timbers, concrete blocks, or rocks. In all cases, the bin should allow air flow through the sides and back. Aeration aids will improve air circulation. Examples include pallets, placing aeration mats or branches under piles and branches, or inserting perforated pipes or wire tubes vertically into the composting materials.

   Several manufactured holding bins are available. Some are intended to compost food scraps. Most of these are closed containers with air vents in the sides. Others have vents only at the bottom and top of the bin. These bins are not designed to maintain aerobic conditions completely. They control odors by enclosing the materials—and the odor—inside the container. Yard trimmings and food scraps are added at the top, and compost is removed from the bottom.
2. Turning bins—Turning units contain the composting materials while providing easy access for turning. Materials are either turned in place or shifted back and forth between adjacent bins. Turning bins are similar to the stationary holding bins described above, but with features such as an open side, removable walls, and multiple bins. Turning units with a series of three bins are popular. Similar to the three-pile system, one bin contains fresh material, the second actively composted material, and the third holds maturing compost.

C. Barrels and Tumblers

Rotating barrels or drums turn the materials inside as they spin like a clothes dryer (via a

hand crank) or tumble end-over-end. There are many manufactured models, although you can make rotating barrels yourself. One commercial model uses a solar-powered electric motor to continuously rotate the drum. Some drums and multisided tumblers are designed to be rolled along the ground. All of these composting units include some means of aeration plus loading and unloading features. Because you must load the barrels in batches, it is necessary to store fresh materials. As an alternative, you can use two drums—while one drum is composting, the other is being loaded with fresh material. Given a large enough batch of material, rotating barrels should generate high temperatures.

The idea behind rotating barrels is to make turning effortless. Therefore, the material will be turned more often and decompose faster. Several manufacturers claim their product can produce finished compost 2 weeks (although 1 month is a more realistic goal). In order to achieve quick composting, other factors including easily degraded and shredded materials, proper moisture, and C:N ratios must accompany the benefits of frequent turning.

IV. Making and Managing a Compost Pile

Composting is a natural and flexible process. It will take place under a wide range of conditions and methods regardless of either the efforts or neglect of human composters. Nevertheless, good management helps the process along and minimizes nuisances. Management determines how soon the compost is produced. For example, turning a compost pile weekly can yield compost in 1 to 2 months, with adequate moisture content and a good combination of materials. Without turning, composting takes 6 months to 2 years. You can make excellent-quality compost either way.

A. Materials

Almost all natural organic materials will decompose, but not everything belongs in the backyard compost pile as you can see in Table 3. Generally, you can compost garden vegetation, landscape trimmings, and most plant-derived food scraps without concern.

1. It is prudent to avoid composting plants harboring disease, or treated with persistent herbicides, or carrying many seeds and insects. Also, it is a good idea to keep out certain noxious weeds, including morning glories (bindweed), and grasses (such as quackgrass) with rhizomatous root systems. Backyard compost piles do not reliably produce the high temperatures necessary to thoroughly kill

Table 3. Materials that you should and should not compost (adapted from NRAES-43, "Composting to Reduce the Waste Stream").

YES	NO
Aquatic plants	**Oily foods** (attract pests)
Bread	Butter
Branches—chipped	Bones
Brush—chipped	Cheese
Coffee grounds	Fish scraps
Corn cobs	Lard
Cut flowers	Mayonnaise
Egg shells	Meat and poultry
Evergreen needles	Peanut butter
Fruit	Salad dressing
Fruit peels and rinds	Sour cream
Garden trimmings	Vegetable oil
Grass clippings	
Leaves	**Possible sources of disease and weeds**
Manure—cattle, horse, rabbit	Cat manure
Paper	Dog manure
Sawdust	Diseased plants
Straw	Plants with rhizomatous roots
Sod	Plants with severe insect infestation
Tea leaves and bags	Weeds that have gone to seed
Vegetables	
Vegetable trimmings and tops	**Possible sources of toxins**
Weeds without seeds	Black walnut leaves
Wood ash	Cedar chips, bark, branches
Wood chips	Grass treated with persistent herbicides
Wool waste	

rhizomes, weed seeds, and plant diseases. For the same reason, do not add cat and dog manure, which may contain pathogens, to backyard piles. Avoid adding fatty and oily foods because they tend to attract animal pests (rodents, skunks, dogs, and cats). Also, oily foods are quick to decompose and may generate odors.

2. Another group of materials to be cautious about are those that may contain natural or manufactured compounds that are toxic to either plants or the composting decomposers. Examples include grass and vegetation containing persistent herbicides, leaves from black walnut trees, and cedar wood. Even if these materials decompose, the compost might retain some of the toxins. If you want to compost these materials, segregate them from the other materials. Also, use the compost only where the toxins will not have a negative effect. For example, use composted walnut leaves as mulch for walnut trees or use herbicide-treated grass compost as lawn top-dressing.
3. The degradability of materials is also a consideration. Highly degradable materials such as grass clippings, food scraps, and manure, require more turning and attention (see odor control). Slowly degradable materials need shredding and time for composting, even with regular turning. Chop or shred before composting branches, plant stems, and other thick or large particles of material. The less degradable a material is, the more important shredding becomes. Also, chop whole pieces of fruit and vegetables to break the protective barrier of the skin or peel.

B. Additives

Some composters add lime, wood ash, inorganic fertilizers, and organic nutrient sources into compost piles to enhance the compost or the composting process. These additives are not necessary to composting. Depending on the compost pile conditions, they may speed the process or provide no benefit at all.

1. Lime—Rarely helpful to the composting process, lime is added sometimes to neutralize acidic materials and organic acids formed during composting. The effect of these acidic conditions, however, is seldom damaging. Composting decomposers can work at a relatively low ph (acidic) and further decomposition tends to push the pH toward neutral. Lime also encourages ammonia loss, especially if the C:N ratio is low (a lot of greens).
2. Wood ash—Although wood ash adds mineral nutrients to the compost, it has little effect on the composting process. Like lime, wood ash increases pH and encourages ammonia loss. Usually, the composting process is not adversely affected by the amount of wood ash that a household wood stove generates.
3. Inorganic fertilizers—Because backyard composting piles usually lack nitrogen, inorganic fertilizers tend to speed the composting process. The compost is not greatly affected. Inorganic fertilizers should be dissolved in water and mixed into the compost pile. You can only approximate the correct amount of fertilizer to add. For example, a pile of dry leaves generally requires about 2.4 ounces of nitrogen per bushel (about 4 cubic feet). Table 4 lists the corresponding amount of various types of fertilizers. Use less fertilizer as you add more greens to the pile. If you add too much fertilizer, nitrogen will be lost to the atmosphere as ammonia or leached from the pile into the ground. In part, this occurs because the

Table 4. Amount of various nitrogen sources needed to supply 2.4 ounces of nitrogen (adapted from NRAES-43, "Composting To Reduce the Waste Stream").

Nitrogen source	Percent nitrogen	Ounces of fertilizer
Ammonium nitrate	33	7.0
Calcium nitrate	15	16.0
Urea	46	5.2
Dried blood	12	20.0
Fish meal	10	24.0

nitrogen from fertilizer is available to the decomposers more quickly than the carbon from the organic materials.

4. Organic nutrient sources—Concentrated organic sources of nitrogen such as manures, dried blood, fish meal, fish emulsion, and cottonseed meal are better sources of nitrogen. Compared to inorganic fertilizers, these sources release nitrogen that more closely matches the availability of organic carbon.

C. Inoculants

Soil, vegetation, food scraps, compost, and the environment contain the desired organisms in ample quantities to start the composting process. Some composters claim to see faster composting after using inoculants. Others have found no difference. In any case, inoculants, activators, or compost starters are not necessary.

D. Location

The pile should not be in contact with trees, wooden fences, and buildings because the compost will accelerate wood decay and metal corrosion. Also, spontaneous combustion (self-ignited fire) within a backyard composting pile is a remote yet possible danger.

1. Shelter—A sheltered location is an asset because wind both cools and dries the pile. Direct sunlight can be undesirable. Although it provides warmth in the winter, sunlight dries the pile in the summer.
2. Water—The location should provide access to water as you will need to water piles frequently during the summer. You are more likely to keep piles moist if the water source is convenient—for example, within reach of a garden hose. Avoid poorly drained locations that gather standing water because materials will become waterlogged.
3. Space—Finally, the location should provide enough space to turn the pile and to stockpile raw materials and finished compost, if necessary.

E. Volume

A pile or bin should be large enough to generate and hold in heat, yet small enough to allow air to reach its center. As a general rule, the minimum pile or bin dimensions should be 3 by 3 feet at the base and 3 feet high. Piles and bins that are larger than 5 feet high or 5 feet wide are difficult to aerate and require more turning.

Pile volume is most important during the cold season. Therefore, start new piles in the summer and gradually enlarge them as winter approaches.

F. Building Composting Piles

You can construct compost piles gradually from the ground up by adding material as they become available, and in batches by stockpiling materials until you have accumulated a certain amount. This is rarely an either/or choice—a pile or bin can grow both gradually and in batches. Adding fresh material in large quantities is more likely to produce high temperatures but it also increases the chance of odors and requires more turning.

1. Mixing or layering ingredients—The most important task in constructing a pile is to mix together the appropriate ingredients, including water. Blend brown and green ingredients well for microorganisms to obtain a balance of both carbon and nitrogen. Some composters add materials without mixing and rely on subsequent turnings to blend the ingredients. Others add brown and green materials in successive layers, 3 to 6 inches thick, with the first and last layers consisting of coarse brown materials as in Fig. 2. Another variation intersperses layers of soil, fertilizer, or manure among the brown and green layers. Layering provides an easy and visual way to proportion materials. The layers, however, make a poor blend of materials. Turning is necessary to mingle the brown and green materials together.
2. Burying materials—When adding to piles continuously, bury materials (certain food scraps) that might attract flies and pests 6 inches beneath the surface of open piles and bins. If the pile is not dry or frozen, the material will partially decompose in 1 to 2 weeks. Then you can turn the pile as desired. When adding food materials in large quantities, mix

them into the pile, cover them, and then turn the pile a week or so later. If you are using enclosed bins and barrels, you do not need to bury materials.

3. Insulating the pile—Placing a layer of coarse material at the base of piles and bins improves aeration and insulates them from the colder ground. The base layer also absorbs liquids that may leak from above. Appropriate materials include dry leaves, corn stalks, straw, wood chips, and compost. You also can use these materials to cover the surface of piles. A 3- to 6-inch outer layer protects piles from heat and moisture loss and helps to contain odors.

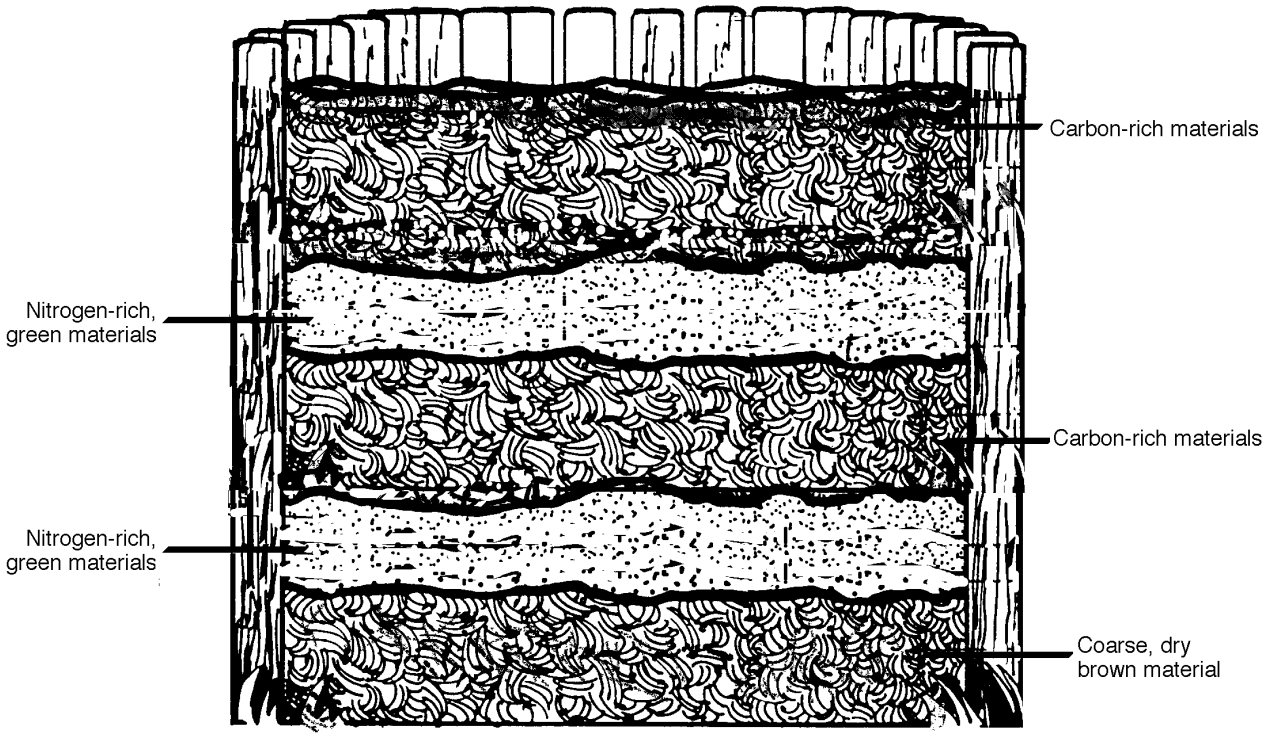
G. Turning

Although turning is not essential to backyard composting, it performs several beneficial functions. It improves aeration by increasing porosity and charging the pile with fresh air. It also blends materials, breaks apart particles, and removes heat, water vapor, and other gases contained in the pile. Turning speeds the process and helps in managing temperature, moisture, and odors.

There are few hard-and-fast rules for turning composting materials. You can do it on a regular schedule (weekly), when you add fresh materials, occasionally at your convenience, or in response to the pile's conditions. Turn piles according to the following guidelines.

1. To speed the process and promote high temperatures—In most cases, the more often you turn a pile, the faster it composts. Therefore, the pile is more likely to achieve high temperatures. Turning is effective with moderately to highly degradable materials. It has limited effect on slowly degradable materials.
2. To blend materials—Turn piles when materials are poorly-mixed, when different sections of the pile show differences in consistency, color, moisture, temperature, or odor.
3. To cool the materials—Turn piles when temperatures become too high (above 140°F).
4. To aerate materials—Turn piles when odors begin to develop (see Subsection I on "Odor Management" on page 7-12) or

Fig. 2. Building compost piles by layering.



when other signs of anaerobic conditions appear such as an unexpected temperature drop or compacted, matted, or slimy-looking materials.

5. To drive off moisture—Turn piles when the materials become saturated from rain or with the addition of wet materials.
6. To add moisture—Turn piles when adding water. Otherwise, water is difficult to distribute throughout the pile.

H. Moisture Management

1. Lack of moisture—The most common ailment of composting piles in arid climates is lack of moisture. Without substantial rain, you must add water to piles (perhaps weekly) to keep the process going. The more you turn a pile, the more water you should add. You can reduce moisture loss by decreasing the turning frequency, sheltering piles from wind and sun, increasing pile size, and using bins with covers and small ventilation openings.
2. Too much water—A less frequent problem, you should turn piles that are too wet to distribute water within the pile and to encourage evaporation.
3. Moisture test—Although the surface of the pile appears dry, the materials a few inches below should look and feel damp. Use the squeeze test to test for adequate moisture (see Section II, Subsection C-2 on page 7-4). If the pile needs water, add it with a trickle hose or sprinkler. Because water moves slowly through the mass of composting materials, turn the compost while adding the water. To conserve fresh water, you can routinely add "used" water from certain household (for example, water from washing or cooking vegetables) and garden activities.

I. Odor Management

Most backyard composting materials present little odor risk. Still, odors can occur as a result of neglect or the wrong combination of materials and conditions. The best way to manage odors is to avoid anaerobic conditions—keep the pile from becoming too wet, turn at the first hint of odors, maintain a mix with at least as much brown material as green, and generally maintain good pile porosity.

1. Degradable materials—Highly degradable materials such as grass, manure, and food scraps require particular attention. Mix the materials thoroughly within the pile. If you add these materials in large quantities (more than one-quarter of the pile volume), then turn the pile regularly. Unturned piles and holding bins do not provide the air flow needed to aerobically decompose large quantities of grass, manure, and food. If turning is not practical or if odors are a sensitive problem, it may be best to avoid composting these materials.
2. Correcting odors—The remedy for an odorous pile is to supply more oxygen by turning and by increasing the pile's porosity (e.g, adding course brown materials). Disturbing the pile will release the odorous compounds, so the odor may become more intense for a brief period. If a pile develops strong odors, turning it might aggravate the nuisance. You can allow the odorous pile to decompose undisturbed and the odors should gradually dissipate. Do not add water or fresh material except for an insulating, odor-absorbing layer of course dry materials on the surface. Instead, start a new pile. When the odorous pile becomes tolerable, turn it and combine it with a new pile.

J. Troubleshooting

The most prevalent problem associated with backyard composting is slow decomposition. The first suspected cause is excessive drying of piles, followed closely by a lack of nitrogen (not enough fresh green material). Poor aeration caused by wet or compacted materials, also can hinder the composting rate. In this case, odors may accompany the problem. Other occasional difficulties include pests, ammonia-like odors, and extremely high temperatures. See Table 5 for troubleshooting guidelines.

K. Judging When Composting Is Finished

Composting does not stop at a particular point. Biological decomposition of the raw materials and the compost continues almost

indefinitely. The compost becomes usable, and we consider the process finished when the decomposition rate slows to the point that the compost will not create odors nor adversely affect plants as it continues to decompose. Judging when the pile reaches this point is part of the art of composting. Signs of mature compost include the following:

1. The expected composting time period has elapsed since you last added materials to the pile (see Section II, Subsection C-7 on page 7-6).

Table 5. Troubleshooting guidelines for home composting piles.

Problem	Possible causes	Clues	Remedy
Rotten odor	Anaerobic conditions because of excess moisture	Pile feels and looks soggy.	Turn pile and/or mix in dry materials.
	Anaerobic conditions because of poor porosity and compaction	Pile looks dense, matted, or slimy with few or no large rigid particles.	Turn pile and/or mix in course brown materials—straw, chipped wood, etc.
Ammonia odor	Too much nitrogen; not enough carbon	Pile includes a lot of grass, food, or manure	Mix in more brown carbon-rich material—leaves, sawdust, etc.
Slow decomposition	Not enough moisture	Pile is barely damp to dry inside.	Add water and/or wet materials and turn pile.
	Not enough nitrogen, **or** slowly degradable materials	There is an abundance of brown materials in the pile—wood, leaves, etc. **and** the pile is not dry.	Add green material or nitrogen fertilizer, **or** shred materials, **or** be patient—it will happen.
	Not enough oxygen—anaerobic conditions	Pile is dense, looks matted or slimy with hint of rotten odor.	Turn pile. Add course or dry material as needed.
	Pile is cold—small volume	Pile is less than 3 ft high and the weather is near freezing.	Add fresh material and turn pile. Increase pile size.
	Pile is totally frozen	Frozen clumps within the pile	Wait for spring, and then turn.
	Compost is mature	Pile conditions are good.	None needed
Not reaching high temperatures (over 120°F)	Small volume	Pile is less than 3 ft high.	Increase pile size.
	Not enough nitrogen	Pile is more than 3 ft high. Weather is above freezing.	Add green material or nitrogen fertilizer.
	Cold weather	Pile is more than 3 ft high; below freezing weather.	Insulate surface of pile with compost, straw, leaves, etc.
Pile is too hot (over 140°F)	Pile is too large	Pile is more than 5 ft high.	Divide into smaller piles.
	Not enough air flow—poor ventilation	Pile is less than 5 ft high, but fairly dense and moist.	Turn pile. Decrease pile size.
	Pile is becoming too dry. Not enough evaporative cooling	Pile is less than 5 ft high and only slightly damp.	Add water and turn pile.
Pests attracted to compost pile (flies, bees, dogs, cats, rodents, skunks, etc.)	Exposed food scraps	Food scraps at or near the pile surface	Bury food 6 inches beneath the pile surface.
	Meat, fish, or oily foods in the pile	Evidence of digging in the pile	Remove food from pile, **or** turn into the pile center, **or** use a pest-proof composting bin.

2. The pile of compost is consistent and has a dark brown color, crumbly texture, and earthy odor.
3. Except for pieces of wood, the compost shows little evidence of the original yard trimmings and food scraps added to the pile.
4. The moist pile remains cool and does not become warmer after turning.
5. Earthworms and other invertebrates have inhabited the compost pile.
6. The moist compost does not develop offensive or stale odors when stored in a closed plastic bag at room temperature for 2 weeks.

Note: Unfortunately, an unfinished compost can exhibit some of these traits. Therefore, be sure several of these signs (the more, the better) are present before harvesting the compost. To be safe, allow the compost to cure in small piles, about 3 feet high, for a month or two after you judge the process to be complete.

V. Using Compost

Use compost as a soil amendment for flower and vegetable gardens, as a mulch around trees and shrubs, as a top-dressing for lawns, and as a component of potting soil. Most compost will greatly benefit plants, but unfinished compost, or compost stored under anaerobic conditions, can harm seedlings or sensitive plants. Therefore, compost quality is important.

A. Benefits of Compost

1. Improves soil structure—The addition of compost gives soil a crumbly texture and increases the soil's porosity so that plant roots can more easily penetrate it. When mixed with a sandy soil, compost adds moisture and nutrient holding capacity. In heavy clay soil, compost particles bind with clay particles to form loose aggregates of soil that drain better and resist surface crusting and erosion.
2. Buffers pH changes—Most composts have a near-neutral pH and the ability to buffer pH changes in the soil.
3. Attracts beneficial soil organisms—Compost contains a large and diverse population of biological organisms plus organic matter that attracts earthworms and other beneficial soil organisms. These traits contribute to compost's ability to suppress certain soilborne plant disease.
4. Contains trace mineral and plant nutrients—Although compost is not normally considered a fertilizer, it does contain trace minerals and small quantities of major plant nutrients. The amounts of nutrients depend on the materials composted. Typically composts made from yard trimmings have N concentrations in the range of 0.5 to 1 percent with P and K ranging from 0.2 to 0.5 percent. Most of the nitrogen and phosphorus are released slowly, over a period of several years, and in a pattern that tends to follow the growth patterns of plants.

B. Application

See Table 6 for general guidelines for applying compost. Because we use compost primarily as a soil amendment and not as a fertilizer, the amount of compost you apply is not critical. As a rule, use more compost for poorer soils.

1. As a mulch or top-dressing—You can apply compost continually as a mulch or top-dressing for gardens and lawns. The organic matter and nutrients will gradually work their way into the soil.
2. As a soil amendment—The best time to add compost as a soil amendment is when you prepare the garden bed or lawn surface before planting. Mix the compost with soil to at least three times the depth of the thickness of the compost layer that you are applying. For example, mix a 1-inch thick layer of compost into the top 3 to 4 inches of soil; mix a 2-inch layer to a depth of 6 inches or more. If only a small amount of compost is available, incorporate it in seed furrows or mix it with soil for each annual or perennial plant's transplant hole following the 1 to 3 compost-to-soil ratio.
3. As a potting mix—Compost should not comprise more than one-third of the pot-

ting mix by volume. A popular compost-based mix is one part peat moss, one part vermiculite or perlite, and one part compost, by volume.

C. Compost Quality

1. Quality depends on use—The required qualities of a compost depend on its intended use. Compost intended as a top-dressing for lawns should not have particles greater than 1/4-inch in size. It is often necessary to pass a top-dressing compost through a 1/4-inch screen. Compost used as a soil amendment can have large particles but should not contain a high percentage of wood. Soil microorganisms compete with the garden plants for nitrogen as they decompose the remaining wood. Gardens that are amended with wood compost require extra applications of nitrogen fertilizer. Compost that looks and feels more like a collection of small wood chips than soil is better suited as a mulch than a soil amendment. Make this judgment after mixing the compost because small particles tend to settle to the bottom of undisturbed compost piles leaving a blanket of wood particles on the surface.
2. Cure compost before using—Immature compost and compost produced or stored under anaerobic conditions may contain organic acids and alcohols that can harm plants. These conditions are not common in backyard composting because piles and bins tend to be small. Nevertheless, it is wise to cure mature compost for a month or more before using it. Store or cure compost in piles that are relatively short—3 feet or less. If you have stored compost in a large pile, spread it on the ground and allow it to air out for a day or more (the longer, the better). Maturity and other quality factors become increasingly important if you use the compost in a more concentrated manner. For example, compost used in potting mixes requires closer scrutiny than compost used as a soil amendment.

VI. Alternatives to Composting

Composting is not the only way to make good use of home and garden residues. Worm composting produces a high quality soil amendment via a different biological process. Grass recycling, soil incorporation, and mulching are other ways to recycle garden and food residues without the management demands of composting.

Table 6. Guidelines for applying compost.

Landscape use	Approximate application rate (lb per 1,000 sq ft)	Equivalent thickness of compost	Comments
Soil amendment for gardens and lawn establishment	3,000 to 9,000	1 to 3 inches	Mix with soil to a depth of about 4 to 9 inches. Use more compost for poor soils.
Soil amendment for planting trees and shrubs	3,000 to 9,000	1 to 3 inches	Mix with soil over an area of 2 to 5 times the root ball width and to a depth of 6 to 10 inches. Use more for poor soils.
Top-dressing for lawns	400 to 800	1/8 to 1/4 inch	Broadcast evenly over lawn surface. Best applied after thatching or core aerifying.
Top-dressing for gardens and shrubs	400 to 1,500	1/8 to 1/2 inch	Spread evenly then lightly work into the soil.
Landscape or garden mulch	1,500 to 6,000	1/2 to 2 inches	Spread evenly over surface. Use the higher rate with coarse woody composts.
Potting mix	Not more than one-third by volume		Blend with peat moss, sand, perlite, vermiculite, or bark.

Helpful numbers: A 1-inch deep layer covering 1,000 square feet requires about 3 cubic yards of compost.
Compost weighs about 30 to 40 pounds per cubic foot (about 800 to 1,000 pounds per cubic yard).

A. Grass Recycling

Usually, the compost pile is not the best destination for grass clippings. The simplest way to recycle grass clippings is to leave them on the lawn. This benefits the lawn by returning nutrients and organic matter to the soil. This alternative also keeps herbicide-treated grass out of the compost pile. "Grasscycling" works best with proper mowing, fertilizing, and watering practices.

B. Mulching

You can use many organic residues from the home, garden, or landscape as mulches with little or no decomposition or preprocessing. Placing organic mulches on the soil surface controls weeds, reduces evaporation, lessens soil erosion, and moderates the soil temperature (keeps it cooler in the summer, warmer in the winter). Types of yard trimmings that you can use as mulches include grass clippings, leaves, pine needles, and chipped branches and shrub-trimmings. All of these materials are suitable for surface mulching around trees, shrubs, and other perennial plantings.

Shred leaves with a lawn mower or commercial shredder before using them as a mulch. Unshredded leaves tend to limit water and oxygen movement into the soil. Apply fresh grass clippings in layers that are not more than 1 inch thick. Otherwise they will mat together and limit air movement. A brief period of composting or drying can approve the appearance and performance of several mulching materials including leaves, grass clippings, and chipped wood.

C. Worm Composting

Worm composting, or vermicomposting, relies on worms to digest food scraps, paper, manure, and vegetation. In the process the worms leave behind castings that form a high-quality soil amendment called "vermicompost." The type of worms used are red worms, not common soil dwelling worms.

Worms need a dark, cool, moist, and aerobic environment. Therefore, mix food and "bedding" in shallow layers in closed boxes or bins to compost. The bedding provides a light, airy habitat for the worms. Typical bedding materials include shredded paper, straw, peat moss, and sawdust. Worms work best at temperatures between 50° and 70°F (10°- 20°C), so a basement or other cool space is a good location for a worm bin. If the bin freezes or gets too hot, the worms die. You can harvest and use the compost when the bin contents become fairly uniform, dark, and soil-like in texture. This usually takes 3 to 6 months.

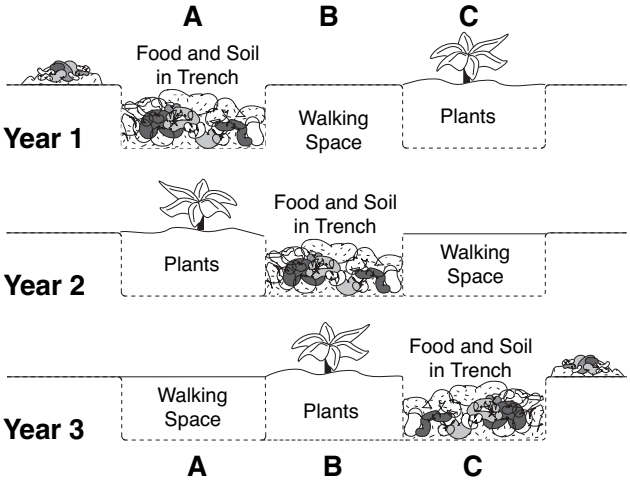
D. Soil Incorporation

Incorporating food scraps into the soil is an alternative method for recycling nonfatty food scraps. Within a month to a year, the food material will decompose to fertilize established or future plantings. The time period depends on the soil temperature, the number of organisms in the soil, and the carbon content of the food. Chop the food scraps, mix with the soil at the bottom of an 8- to 12-inch deep hole or trench, and cover completely with clean soil. One system of soil incorporation rotates garden space among food trenches, rows of crops, and walkways as in Fig. 3. Soil incorporation is difficult, if not impractical, during the winter when ground is frozen or snow covered.

VII. Plans for Constructing Composting Bins

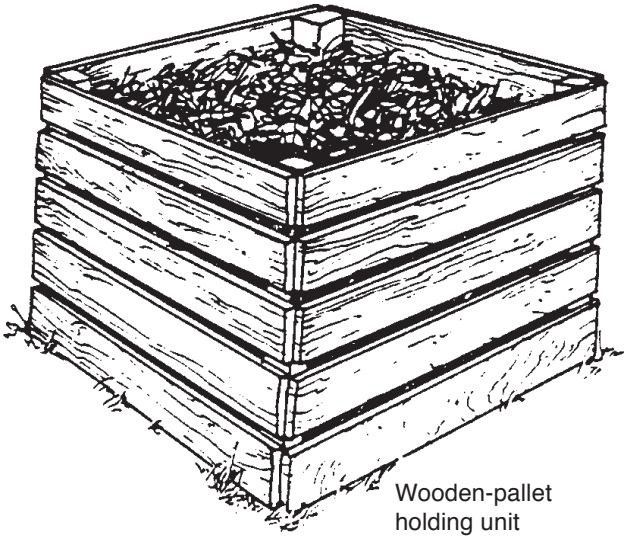
You can make compost bins from readily available materials. Types of enclosures include woven-wire fencing (hog wire, chicken wire, chain link), wood-slat fencing (snow fence), cement blocks, bricks, or scrap lumber.

Fig. 3. Soil incorporation of food scraps—rotating-trench method.



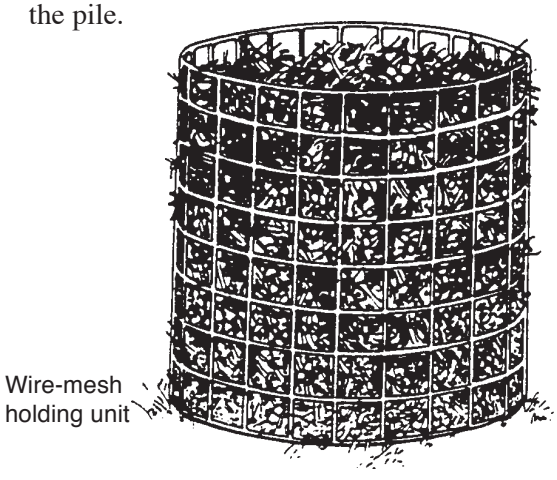
A. Wooden-Pallet Holding Unit

You can build an inexpensive compost bin with wooden pallets or pressure-treated lumber. Used pallets are available from manufacturers and landfills.



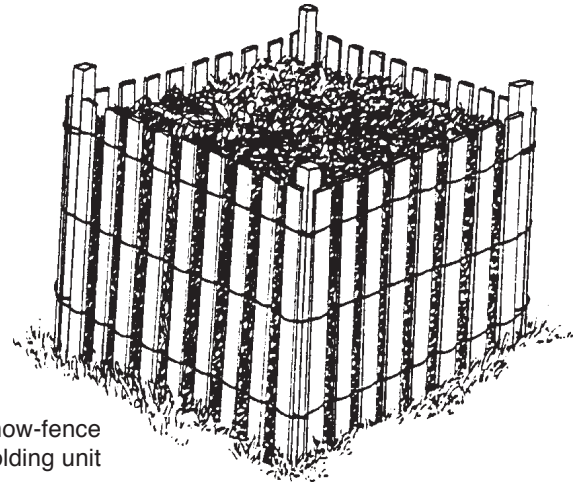
B. Wire-Mesh Holding Unit

Use either galvanized chicken wire or hardware cloth to build an inexpensive wire-mesh holding unit. (You also can use nongalvanized chicken wire, but it won't last very long.) Posts provide more stability for a chicken wire bin, but make the bin difficult to move. A wire-mesh bin without posts is easy to lift and provides access to the already "done" compost at the bottom of the pile.



C. Snow-Fence Holding Unit

A snow-fence holding unit is simple to make. It works best with four posts pounded into the ground for support.



D. Wood-and-Wire, Three-Bin Turning Unit

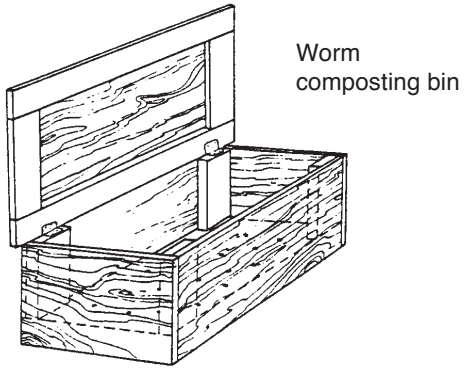
You can use a wood-and-wire, three-bin holding unit to compost large amounts of yard, garden, and kitchen wastes in a short time. Relatively inexpensive to build, it is sturdy, attractive, and should last a long time.

E. Wooden Three-Bin Turning Unit

This turning unit is a permanent, sturdy structure made of pressure-treated lumber.

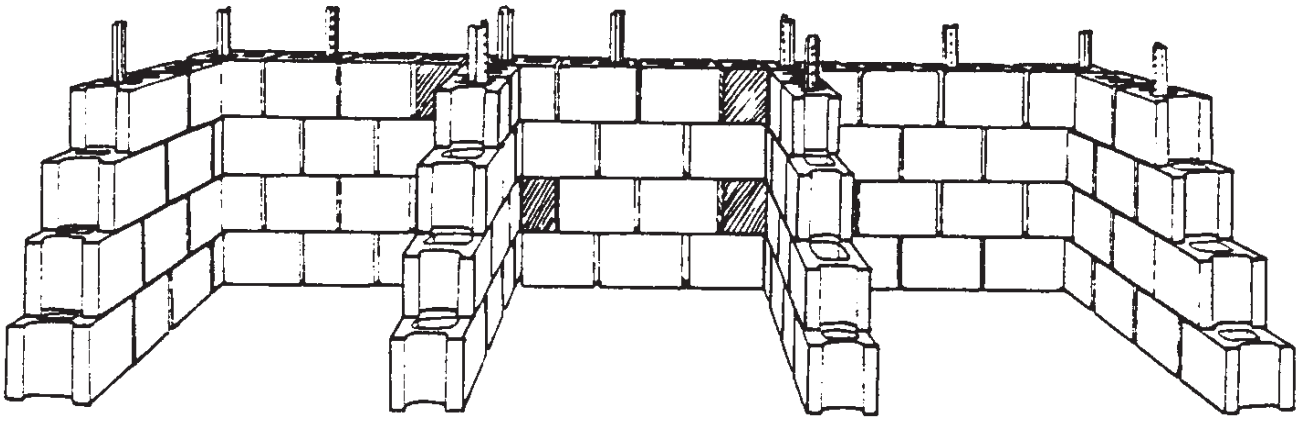
F. Worm Composting Bin

Worm composting is a suitable option for apartment buildings or homes with no yard space. The worms stay in the bin and eat household scraps, and the bin gives off little odor.



G. Concrete-Block Holding Unit

A concrete-block holding unit is sturdy, durable, and easily accessible. Leave about 1/2 inch between each block to let in air. Stagger the blocks and drive wooden or metal posts through the holes in the blocks to stabilize the bin.



Concrete-block, three-bin turning unit

H. Concrete-Block, Three-Bin Turning Unit

A concrete-block turning unit looks like three concrete-block holding units in a row. It is sturdy and, if used blocks are available, it is inexpensive to build.

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Chapter 9

PESTICIDE MANAGEMENT AND SAFETY



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Chapter 9
Pesticide Management and Safety

Vickie J. Parker-Clark, Former District I Extension Director, Coeur d'Alene

I. Three Main Objectives of Pest Control

A. Prevention—Keep a pest from becoming a problem.

B. Suppression—Reduce pest numbers or damage to an acceptable level.

C. Eradication—Destroy an entire pest population.

II. Home, Yard, and Garden Pesticides

Pesticides are used to prevent or reduce damage caused by weeds, diseases, insects, mollusk, or vertebrates. **Before** you use a pesticide you should:

A. Identify the pest. Remember various pests cause similar symptoms; environmental conditions may cause similar symptoms to pests. **Be a detective.** Ask questions to focus in on the most likely possibilities.

B. Know what other control measures are available (mechanical, chemical, and biological).

C. Evaluate the benefits and risks of each method of control.

D. Choose the methods that are most effective and that will cause the least harm to people and to the environment.

E. Use the methods correctly.

F. Observe local, state, and federal regulations that apply to the situation.

G. Observe precautions, restrictions, and preharvest intervals noted on the label.

III. Pest Control Methods

A. Many factors influence or affect pest control.

1. Climate.
2. Natural enemies.
3. Topography.
4. Food and water.
5. Water supply.
6. Host resistance.
7. Cultural control by mechanical sanitation or crop rotation.
8. Chemical control.

B. The term "pesticide" refers to any substance that is used to control organisms considered to be pests. The following are some of the classes of pesticides available to homeowners:

1. Herbicides—Vegetation control.
2. Insecticides—Insect control.
3. Fungicides—Fungus control.
4. Rodenticides—Rodent control.
5. Acaricides—Mite control.
6. Nematocides—Nematode control.
7. Molluscicides—Snail and slug control.
8. Repellents—Birds, mammals, and insect control.
9. Desiccants and defoliants—For drying plant foliage.
10. Disinfectants—Bacteria and fungi control.

IV. Herbicides

A. Plant life cycle dictates which chemical to use and when to use it.

1. Annual—1-year life cycle.
   a. Winter annuals: Examples are annual bluegrass, henbit, cheatgrass.
   b. Summer annuals: Examples are crabgrass, pigweed, lambsquarters.
2. Biennials: 2-year life cycle. Example: mullen.

3. Perennials: Live more than 2 years. Example: Canada thistle.

B. Types of Herbicides
   1. Selective—Specific to certain weeds or groups of weeds.
   2. Nonselective—Kills all vegetation.

C. How Do Herbicides Kill?
   1. To be effective an herbicide must reach and stick to the leaf, penetrate the surface, move to the site of action, and disrupt a vital process.
      a. Only 1 percent of the herbicide reaches the plant surface.
      b. Surfactants help an herbicide stick to the leaf and penetrate the surface.
      c. Herbicide movement depends on plant age and life cycle and on the mobility of the herbicide.
      d. Many herbicides are taken up by the roots. Example: triazines.
      e. Other herbicides are "pre-emergent." They kill the emerging seedling. To be effective, these herbicides must form a barrier against emerging plants. They will not work if that barrier is disturbed. They will not hurt plants already out of the ground.
   2. Nutrient/water movement at various stages of plant growth: In young plants movement is from the roots upward; in older plants movement is from the roots upward and from the leaves downward. In most mature plants, the movement is downward.
   3. Types of chemicals.
      a. Immobile.
      b. Xylem mobile.
      c. Phloem mobile.
      d. Ambimobile (xylem and phloem mobile).

V. Insecticides

A. Classes
   1. Organophosphates.
   2. Chlorinated hydrocarbons.
   3. Carbamates.
   4. Botanicals.

B. How do insecticides work?
   1. Organophosphates—Affect nervous system.
      a. Several of the organophosphates are systemic. Others are contact.
      b. Organophosphates are detoxified rapidly in animal tissues and are eliminated rather than being stored in fatty tissues.
      c. Organophosphates persist in the environment for relatively short periods in soils and plants. They are broken down by the action of plant enzymes, sunlight, air, moisture, and microorganisms. Some microorganisms (bacteria, yeast, and fungi) are capable of using insecticides as an energy source. Information on the pesticide label concerning the interval required between application and harvest (preharvest interval) is a good indication of the persistence of the material.
   2. Chlorinated hydrocarbons—Affect nervous system.
      a. Are not broken down rapidly in animals, so are stored in fatty tissues.
      b. Are more persistent in plants and soils than other groups of pesticides. Some remain for several years in the soil and for weeks or months in plants. They are not readily attacked by enzymes in plants or microorganisms in the soil.
   3. Carbamates—Affect nervous system.
      a. Some carbamates are systemics.
      b. They are rapidly detoxified and eliminated from the animal's system. Carbamates are not known to accumulate in fat.
      c. Persistence varies in soils and plants, from a few hours to several weeks.
   4. Botanicals—Derived from plants. Examples: pyrethrum, nicotine (highly toxic), and rotenone (will kill fish). Use same handling and safety precautions for these as you would for any pesticide (see Section X, "Pesticide Hazards," on page 8-5 and Section XI, "Pesticide Law," on page 8-8).
   5. The timing of insecticide application depends on the life cycle stage of the insect you are trying to control and on what kind of insecticide you use (systemic or contact).

a. Example: Aphids feeding on a maple tree. A contact chemical (labeled for aphids on maple) applied directly to the aphids will kill any aphids not in the egg stage.

b. If a systemic is used, the sap in the tree must be moving to the leaves where the aphids are feeding in order to kill them. Example: A systemic would not kill the adult stage of the leaf skeletonizer because the adult does not feed on the tree. The larval stage does.

Note: You must know the insect life cycle, the plant life cycle, and the "mode of action" of the insecticide you are using to accomplish the most effective and safe control.

VI. Fungicides

A. Ingredients—Sulfur, captan, triforine, Daconil 2787.

B. How do they work? By suppression or smothering?

VII. Pesticide Labels

A. All home, yard, and garden pesticides are made up of materials from one of two categories:

1. Active ingredient(s)—This component consists of the ingredient that will prevent, destroy, repel, or mitigate any pest.
2. Inert ingredients—This component consists of a wide variety of materials that do not have any biological effect upon the pest. Some common inert ingredients are petroleum distillates, emulsifying agents (detergent-like materials), spreaders, stickers, clay particles, and even water.

B. Pesticide labels are required by law to provide the buyer with a list of active ingredients in a product, and a description of the percentages of the total that those active ingredients make up.

C. Pesticide labels must also state the pest that the product will control and at what rate the product should be applied for safe control of that pest on that plant.

D. Pesticide labels must also give information about storage, disposal, precautions during use, symptoms of poisoning, physical hazards, environmental hazards, preharvest intervals, signal words (caution, warning, danger), and first-aid information. These items will be discussed later in this chapter.

VIII. Pesticide Categories

All pesticides are classified as either "general use" or "restricted use."

A. General Use Pesticides—Considered minimally hazardous when used according to label directions. All home, yard, and garden pesticides are general use.

B. Restricted Use Pesticides—Deemed excessively hazardous to the environment or to the applicator.

1. In Idaho, restricted use pesticides may only be used by those people who have been trained and tested by Idaho Department of Agriculture personnel. These people must show a valid applicator's license to a chemical dealer before purchase of this category of pesticides.
2. Application of restricted use pesticides by unlicensed personnel is a violation of Idaho law.
3. Application of restricted use pesticides in or around the home is risky business, given the high toxicity or wide range of action these chemicals have.

IX. Pesticide Formulations

Pesticide formulations are classified according to the composition of active and inert ingredients and the intended use.

A. Pesticide formulations requiring no dilution in water. These products include:

1. Dusts—Active ingredient combined with inert materials such as fine clay particles, talc, etc.
2. Granules—Active ingredient combined with inert materials such as coarse clay particles, marble chips, or corn cob grit.
3. Baits—Active ingredient combined with an attractant such as food or scent.
4. Pest strips—Active ingredient impregnated in a plastic strip that slowly releases pesticide into the atmosphere.
5. Aerosols—Active ingredient combined with petroleum distillates and propellant gas in a pressurized can.

6. Ready-to-use liquids—Active ingredient already diluted with water at the proper use rate.

B. Pesticides requiring dilution in water. These products include:

1. Emulsifiable concentrates (EC)—Water-insoluble active ingredient, usually in petroleum distillate with emulsifiers. When the distillate is combined with water, it forms an emulsion. Agitation is needed to provide an even distribution of the chemical in water. Emulsifiable concentrates are the most dangerous formulations to handle.
2. Wettable powders (WP)—Water-insoluble active ingredient sprayed on very fine solid particles, usually clay or talc. Add wetters and other adjuvants to aid in the dispersion and suspension of the particles in water. The powders need agitation to mix.
3. Water-soluble liquids (WS)—Active ingredient is dissolved in a concentrate containing alcohol or water. The mix forms a true solution and needs little or no agitation after mixing thoroughly.
4. Dry flowable (DF)—The active ingredient is packaged in granular form. The chemical may or may not be water soluble. DF's are as easy to measure as a liquid and are less likely to contaminate body, clothing, or work area and to be inhaled than either WPs or dusts.

X. Pesticide Hazards

The degree of hazard associated with pesticide use is determined by various factors. The primary concern, however, must be the hazard to the health and welfare of humans. The major factors that determine the hazard of a pesticide to humans, other mammals, and other animals include the following:

A. Pesticide Toxicity (The degree to which a chemical tends to be poisonous)

1. The toxicity of any substance is expressed in terms of dosage.
   a. Hazardous doses vary with such factors as age, sex, health, and body weight.
   b. Dosages are normally expressed in milligrams (mg) of toxicant per kilogram (kg) of body weight (1 kg = 2.2 lb; 1 mg = one millionth of a kg).
2. The toxicity of a pesticide is determined by subjecting test animals (usually mice or rats) to the pure active ingredient.
   a. A common measure of the estimated toxicity of a pesticide is the dose required to kill half the animals treated with a pesticide. This dose is termed to be the LD_{50} (lethal dose to kill 50 percent).
   b. An LD_{50} is always expressed as mg/kg or g/kg. An LD_{50} of 3 mg/kg means that a dose of 3 mg of pure toxicant per kg of animal body weight will normally be lethal to half of the test animals.
3. Pesticide classifications based upon LD_{50} ratings are listed in Table 1. Almost all home, yard, and garden pesticides are category III or IV chemicals. Nicotine has an LD_{50} of 50 to 60 mg/kg so is a class II chemical. Pyrethrum's LD_{50} rating is 1,500 mg/kg.

B. Pesticide Formulations

1. As previously described, almost all pesticides are marketed in formulations that contain considerably less than 100 percent of the active ingredient. The hazard, therefore, of even a category I chemical in a typical home, yard, or garden formulation would be small.

Table 1. Pesticide classifications based upon LD_{50}.

Toxicity category	Signal word	Toxicity	Oral LD_{50} (mg/kg)	Amount needed to kill an adult
I	DANGER POISON (fatal)	Very high	50 or less	A taste to a teaspoon
II	WARNING (may be fatal)	High	51 to 500	A teaspoon to a tablespoon
III	CAUTION	Moderate	501 to 5,000	An ounce to a pint
IV	CAUTION	Low	Greater than 5,000	A pint to a quart or more

2. Some formulations pose a lower hazard than others, simply because of their physical state. For example, a granular pesticide will normally pose a lower hazard than an emulsifiable concentrate because it is more difficult to ingest or absorb through the skin.

C. Exposure to Pesticides

1. Pesticides can enter the body through one of three methods:
   a. Through the digestive tract (ingestion).
   b. Through the respiratory system (inhalation).
   c. Through the skin (dermal absorption). Eyes absorb almost any chemical that gets into them.
2. The hazard of unnecessary exposure to a pesticide can be reduced by following these guidelines:
   a. Replace leaky hoses, valves, and connections on sprayer before application. Never use your mouth to blow out clogged lines or nozzles.
   b. Calibrate and clean application equipment to ensure accurate and safe application.
   c. Always read the entire label before using a pesticide.
   d. Pesticide handling and mixing should be done outside. Watch out for wind when mixing or applying pesticides. Avoid breathing dust, and watch out for the splash of liquids or the drift of fumes.
   e. Refrain from smoking, eating, or drinking while working with pesticides.
   f. Wear clothing that covers the entire body, including a nonabsorbent hat.
   g. Wear unlined rubber gloves and eye protection whenever mixing pesticides.
   h. Before making outdoor pesticide applications: Close all house doors and windows; remove any laundry, toys, lawn furniture, and pet dishes; and keep children and pets out of the sprayed area until the pesticide has dried. If using a dust formulation, keep children and pets out of the area until dust completely settles.
   i. Before making indoor pesticide applications: Remove or cover all food, dishes, utensils, pet dishes, and toys; keep children and pets out of the application area. If you have an aquarium, cover it, and be sure to switch off the aeration pump; cover any openings.
   j. Always apply pesticides in a manner that will minimize pesticide drift onto nontarget vegetation and the property of others.
   k. Wash yourself, your equipment, and your clothing immediately upon completion of pesticide applications. Always wash contaminated clothing separately from other clothing.

D. Pesticide Poisoning

1. People vary considerably in their susceptibility and reactions to pesticides. Children are particularly susceptible because of their small size and weight. A dose that might make an adult sick could be fatal for a child. In addition, a child's body is often less able than an adult's to detoxify some compounds.
2. The common symptoms of pesticide poisoning are headaches, giddiness, nausea, blurred vision, and chest pains. Anyone complaining of these symptoms within 12 hours after exposure to a pesticide should be sent to the nearest medical facility.

Note: It is very important that the pesticide label or container (or at least the name of the compound) also be delivered to the doctor so appropriate first aid can be administered. If the container is transported, carry it in such a way that no further exposure to the victim or others occurs.

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3. Emergency first-aid procedures for pesticide poisoning:
   a. Pesticide in the eyes: Flush eyes with a gentle stream of tap water for at least 15 minutes.
   b. Pesticide in the mouth: Flush mouth out with tap water for 15 minutes.
   c. Pesticide spilled on clothing: Remove clothing; wash skin with soap and water.

d. Pesticide swallowed: Read and follow the first-aid directions on the label. If there are no directions, go directly to the nearest medical facility.

Note: Drinking water or milk will rarely increase the problem and may reduce the potential damage by diluting the chemical.

E. Pesticide Spills

1. Liquids.
   a. The spill should be covered with any substance that will absorb the pesticide (kitty litter, sawdust, sand, dirt, or even disposable diapers).
   b. After the pesticide has been absorbed, the material should be swept up and placed in a plastic garbage bag within another garbage bag. If the pesticide is a home, lawn, or garden formulation, the bag may be disposed of via your standard garbage collection service.
   c. The spill area should then be washed with detergent or an ammonia solution. Call Chem Trec toll free at 1-800-424-9300 to find out what to use. Using the wrong solution could generate toxic gases. Prevent any contaminated soil from running into storm drains or open bodies of water.
2. Dry pesticides should be swept up and used or disposed of in accordance with the label instructions. The spill area may also require washing with detergent or a chlorine or ammonia solution.

F. Pesticide Storage

1. Store pesticides in a cool, well-ventilated place that is inaccessible to children and pets. The area should be away from food, feed, and seeds, and should be locked.
2. Store pesticides in their original containers. Never store pesticides in soft drink bottles or other containers that may be confused with foodstuffs. Always maintain a label on the container.

Note: It is illegal to store chemicals in anything other than their original containers.

3. Discard unidentified pesticides.
4. Store liquid pesticides in a place where they will not be exposed to temperatures below freezing or above 80°F. Heat can degrade the active ingredients in dusts, granules, and soluble powders.
5. Be sure caps are secure on bottles or cans and check regularly for leakage.
6. Do not store volatile herbicides with dry pesticides, as the volatile products may contaminate the other products.

G. Pesticide Disposal Options

1. The best way to dispose of excess pesticides is to use them up in accordance with label directions. Buy small quantities—only the amount you can use up in one season.
2. Neutralize the pesticide if there are directions on the label for doing so.
3. Do not dump pesticides into a public sewage system via the sink or the toilet. Do not dump them into a street gutter that drains into open water. Sprayers should also not be drained near a well, pond, irrigation ditch, or stream.
4. Do not discard pesticide or containers where soil, crops, water, or animals can become contaminated.
5. Before disposing of a pesticide container, triple rinse it. The pesticide contaminated water (rinsate) should be used in your sprayer. Never dump rinsate onto the ground, into a drain, or into a gutter.
6. Puncture or crush empty metal containers (except aerosol cans), and bury them in an approved landfill. Do not burn.
7. Empty and triple rinsed containers may be wrapped in newspaper and disposed of via your local garbage collection service. Rinsate should be used for diluting more pesticide, if possible.
8. Anyone wanting to dispose of unused pesticides should contact their local health department for proper disposal instructions.

XI. Pesticide Law

The primary law homeowners should be aware of regarding safe use of pesticides is the Fed-

eral Insecticide, Fungicide, and Rodenticide Act (FIFRA).

A. This law regulates all pesticides from the time of their manufacture until their ultimate degradation.

B. The most important part of this law, as it pertains to homeowners, involves the actual use of any pesticide. **FIFRA states, "any use of a pesticide in a manner inconsistent with label instructions is a violation of this Act."**

C. All pesticide users should be aware that they are subject to the provision of FIFRA.

XII. Pesticide Recommendations

Before recommending the use of any pesticide, consider the following:

A. It is illegal to use a pesticide on any site or crop other than those listed on the pesticide label. It also is illegal to recommend a pesticide on a site or crop other than those listed on the pesticide label.

Example: A client asks if it is all right to eat a vegetable that was sprayed with a particular insecticide. You find that the pesticide in question is not labeled for use on this garden product. You tell your client that you cannot recommend eating that vegetable, even though you may feel that the hazard is minimal.

B. **In your capacity as a Master Gardener, your pesticide recommendations must be made in accordance with the pesticide guidelines provided on the pesticide label.** Extension publications and the Pacific Northwest pest control guides are based on pesticide labels.

C. Your pesticide recommendations must be limited to home, yard, and garden pest control. Pesticide recommendations for agricultural or commercial pest problems may be made only by licensed consultants.

Further Reading

Books, Booklets, and Pamphlets

University of Idaho Extension

Pacific Northwest Insect Management Handbook

Pacific Northwest Plant Disease Management Handbook

Pacific Northwest Weed Management Handbook

PNW 320 Calibrating and Using a Backyard Sprayer

PNW 512 Farm Safety Series (English)

PNW 512S Farm Safety Series (Spanish)

PNW 278 First Aid for Pesticide Poisoning

CIS 781 Laundering Pesticide-Contaminated Clothing and Safety Equipment

CIS 1019 Pesticides for the Home Garden and How to Use Them

CIS 861 Pesticides in Idaho Groundwater: Monitoring, Protection, and Prevention

CIS 865 Pesticides and Their Movement in Soil and Water

CIS 1030 Storing and Disposing of Home and Garden Pesticides

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Chapter 10
Basic Entomology

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I. Introduction

The animal kingdom contains many distinct groups called phyla. Each phylum is divided into a number of classes. The insects are in the class Insecta (or Hexapoda—"six feet") within the phylum Arthropoda (jointed foot). The insect class is further divided into orders, families, genera, and finally, species.

Approximately 1 million species of insects have been identified to date. The greatest numbers of these species belong to the beetle, fly, and wasp-bee-ant groups. We generally associate insects with crop loss or disease transmission; however, insects fulfill a useful function in our environment.

Only a small percentage of insects are considered pests of humans and of their animals, crops, or fiber. However, this small number can cause serious crop losses, or transmit serious diseases to humans or animals.

Most insects appear to be beneficial or harmless. Many are predators, such as lady beetles, which live by feeding on pestiferous aphids. Others are parasitic, such as the wasps. Still others, such as honey bees, act as pollinators of crops and also provide us with honey. Many insects are responsible for the decomposition of plant and animal matter. A good example is the carpenter ant. Obviously, when it is attacking the timber of our home it is a pest, however, when it is in the forest mining the wood of old, fallen trees, it is part of nature's recycling program.

Size is quite variable throughout the insect world. The extremes include tiny wasps that are less than a millimeter long, and some of the larger long-horned beetles that are as much as 6 inches long.

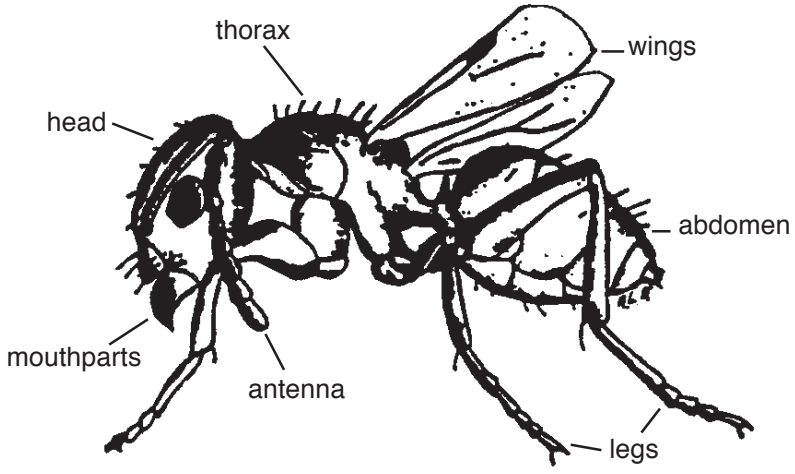
Except for a few common structural features, insects are also variable in appearance. Some have bizarre horns and spines, while others may resemble dead leaves. Some insects are quite attractive like the butterfly, but "beautiful" is hardly the word for a cockroach.

All of this makes insects a fascinating group to investigate, but it also makes the study of insects and their classification somewhat complex. It is important to learn the main differences among insects, so that we can distinguish one group from another. Then we can suggest adequate control procedures and give quality management suggestions.

II. Insect Anatomy

Insects are animals, however, unlike many animals, they have no backbones. They have an **outer** skeleton (**exo**skeleton) instead of the inner skeleton (**endo**skeleton) of most large animals. The following characteristics separate insects from other animals (Fig. 1).

Fig. 1. Parts of an insect.



A. Insects have three body regions—Head, thorax, and abdomen.

B. Many adult insects have wings, and insects are the only flying invertebrates.

C. Adults possess three pairs of legs, all located on the thorax.

III. Insect Development

All insects change during growth by a process called metamorphosis (Fig. 2). Insect nearrelatives such as spiders, mites, and centipedes also undergo metamorphosis.

The more highly developed insects make the most complete changes. Beetles, moths, butterflies, wasps, and ants all go through four stages. These are the egg, larva, pupa, and adult. The larva is usually the damaging stage, although adult feeding can be destructive. Also, it is not unusual for the larval and adult stages of a species to feed on different hosts or different parts of the host. The pupa is a nonfeeding stage; in most cases it is also very inactive.

The lower forms or less-developed kinds of insects change only slightly during metamorphosis. True bugs, aphids, grasshoppers, termites, earwigs, stoneflies, etc., go through only three stages. These stages are the egg, nymph, and adult. Except for size, the nymph and adult closely resemble each other. The major difference is the lack of fully formed wings in the nymph. The nymph and adult generally feed on the same host or host parts.

IV. Insect Classification

There are several methods of separating or categorizing insects.

A. The professional uses body parts for identification and observes differences in these parts through a microscope. He or she tracks down an insect's identity by using a written insect "key." The anatomy of an insect will place it into a specific insect group called an **order**. If you are around entomological activities much, you will often hear the phrase "keying out." This simply means identifying the insect (see MS 109 in "Further Reading").

B. Insects are also classified by the type of damage they cause. Some examples include "root maggot," "twig girdler," or "crown borer." Destructive insect activities help narrow down the multitude of possible identities and often make insect identification quicker and simpler.

C. Some insects can be categorized as predators or parasites. Predators and parasites account for much of the reduction of pest insect populations in nature, and, for this reason, are also called beneficials (see PNW 343 in "Further Reading").

Beneficials can be useful, but they usually need some cultural encouragement. Their use requires careful crop management and a degree of tolerance for some crop loss.

1. Predators kill and feed on their prey; they are generally larger than their prey.
2. Parasites are usually smaller and often weaker than their prey; they gradually kill by injecting eggs that develop on, within, or near the insect over a period of time. They may sting and paralyze their prey in order to stock their nests with food for the developing larvae or eggs. The immature parasites will then consume the paralyzed insect at their leisure.

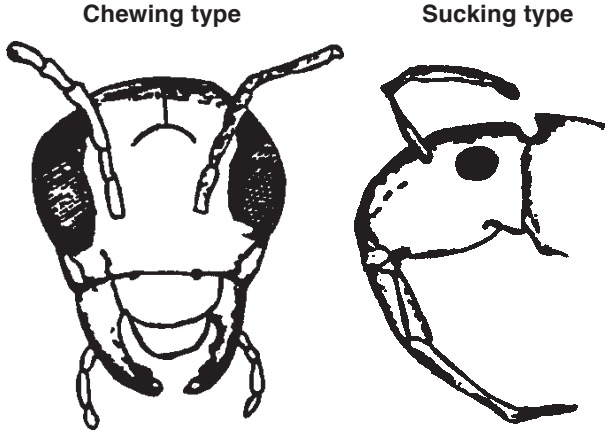
D. Another form of categorization is by feeding mechanism or mouthpart. The broadest grouping is defined by chewing or sucking mouthparts (Fig. 3).

Fig. 2. Metamorphosis stages in insects.



Complete metamorphosis | **Gradual or incomplete metamorphosis**

Fig. 3. Insect feeding mechanisms.



Although this manner of separation is somewhat helpful for identification, its greatest value is in determining if a certain kind of pesticide will work. For example, systemic insecticides "generally" do not work as well on chewing insects as on sucking insects.

Proper identification is extremely important. If a beneficial insect or a nondamaging insect is improperly identified as a pest, a pesticide application will usually disrupt a natural control agent. The disruption of this beneficial's activity may induce the need for the chemical. Chances are you may have made an application that did no more for you than cost you money.

Note: Do not make recommendations based on the verbal description of a pest by a client. Too many misidentifications are made this way, and wrong identification leads to ineffective control measures and unnecessary expense or problems. Insist on seeing the pest, or at least its damage, before you volunteer anything.

V. Major Orders of Insects

Major insect groupings under the class level are called orders. Some representatives that you will see are: beetles—Coleoptera; moths and butterflies—Lepidoptera; flies—Diptera; bees, ants, wasps, hornets—Hymenoptera; true bugs, such as stink bugs—Hemiptera; aphids, scales, and leafhoppers—Homoptera; grasshoppers, crickets, and cockroaches—Orthoptera; termites—Isoptera; earwigs—Dermaptera. There are many other insect orders, but these are representatives of economic importance.

Separating groups of insects may be quite difficult unless you have closely studied examples of the various types. It is important to recognize the structural characteristics that distinguish one insect from another (see "Further Reading"). Use all of the characteristics listed in Table 1 to distinguish each order.

A. Beetles and Weevils—Coleoptera

Some of the typical beetles that you may see are long-horned beetles and flatheaded borers that bore into trees, logs, and lumber. These beetles are variable in color. Long-horned beetles usually have long antennae and are strong fliers. Lady beetles are about 1/4-inch long and are usually red or orange, generally with spots. Lady beetles are beneficial as larvae and adults, since they feed on aphids and other soft-bodied insect and mite pests. Some other common beetles are the pea weevil, an important pest of peas, and click beetles, whose larvae are known to some of you as wireworms.

Table 1. Major order of insects.

Name of order	Common examples	Wings/mouthparts
Coleoptera	Beetles, weevils	2 pairs wings or wingless; chewing
Lepidoptera	Moths, butterflies	2 pairs wings; chewing (larvae), sucking, or siphoning (adults)
Diptera	Mosquitoes, flies, and gnats	1 pair wings; chewing (larvae), piercing-sucking, or sponging (adults)
Hymenoptera	Wasps, bees, ants, and sawflies	2 pairs wings or wingless; chewing
Hemiptera	Bed bugs, stink bugs, and cinch bugs	2 pairs wings; piercing-sucking
Homoptera	Aphids, leafhoppers, scales, mealybugs	2 pairs wings or wingless; piercing-sucking
Orthoptera	Grasshoppers, crickets, and cockroaches	2 pairs wings or wingless; chewing
Isoptera	Termites	2 pairs wings or wingless; chewing
Dermaptera	Earwigs	2 pairs wings or wingless; chewing
Thysanura	Silverfish, firebrats	Wingless; chewing
Thysanoptera	Thrips	2 pairs wings or wingless; rasping-sucking
Collembola	Springtails	Wingless; chewing
Psocoptera	Barklice, booklice	2 pairs wings or wingless; chewing
Mallophaga	Chewing lice	Wingless; chewing
Anoplura	Sucking lice	2 pairs wings or wingless; piercing-sucking
Siphonaptera	Fleas	Wingless; chewing (larvae), piercing-sucking (adults)

1. Adults have a hardened, horny outer skeleton.
2. Adults have two pairs of wings; the outer pair is hardened, and the inner pair membranous.

Note: A few beetles are practically wingless, and some have only an outer hard pair of wings.

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3. Beetles have chewing mouthparts.
4. Adults usually develop noticeable antennae.
5. Coleoptera larvae have a head capsule and three pairs of legs on the abdomen.

Note: Weevil larvae lack legs on the thorax.

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6. Both beetles and weevils go through a complete metamorphosis as in Fig. 4.
7. Some authorities consider the beetles to be the largest group or order of insects in nature.

B. Moths and Butterflies—Lepidoptera

The moth and butterfly group has several damaging members. Cutworms damage many crops. For example, corn earworm larvae, which are greenish or tannish with some stripes and about 1 1/4-inch long when fully grown, cause severe damage to corn and attack a variety of vegetables.

Alfalfa, celery, and cabbage loopers have injurious larvae. They are often known as measuring worms because of their looping action, which gives the impression that they are measuring the plant on which they are feeding.

Another Lepidoteran is the codling moth, which does damage to apples. The peach twig borer is a severe pest of peaches, prunes, plums, and apricots.

1. Adults are soft-bodied with four well-developed, membranous wings covered with small scales.
2. Adult mouthparts consist of a coiled, sucking tube; adults feed on nectar and other liquids.
3. The larvae are caterpillars that are worm-like, and variable in color; they are voracious feeders.
4. The larvae have chewing mouthparts.
5. The larvae have true legs on the thorax and a variable number of prolegs on the abdomen.
6. Lepidopterans undergo complete metamorphosis as in Fig. 5.

C. Flies, Mosquitoes, Gnats, Midges—Diptera

Flies are an important group in terms of their medical effects on humans and animals. Some, such as bot flies, are parasites as immatures on mammals. Some flies, such as the face fly, disrupt or annoy livestock, causing the cows or other animals to stop feeding. Fly maggots or larvae are generally found in manure or other decaying matter.

The flies most commonly encountered are the housefly, the lesser house fly, and the face fly. The grayish adults infest homes, poultry houses, and livestock. The house fly has been suspected of mechanically transmitting such diseases as polio to food surfaces.

Fig. 4. Metamorphosis of a beetle.

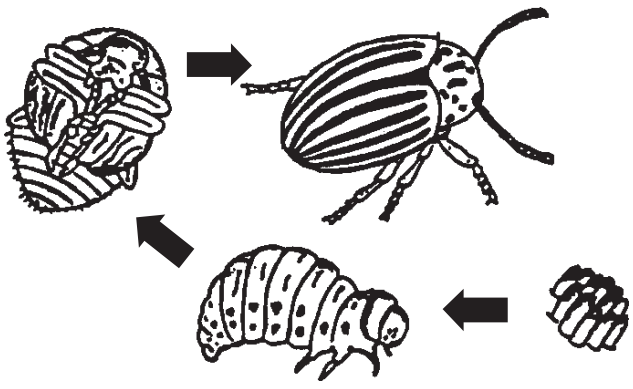
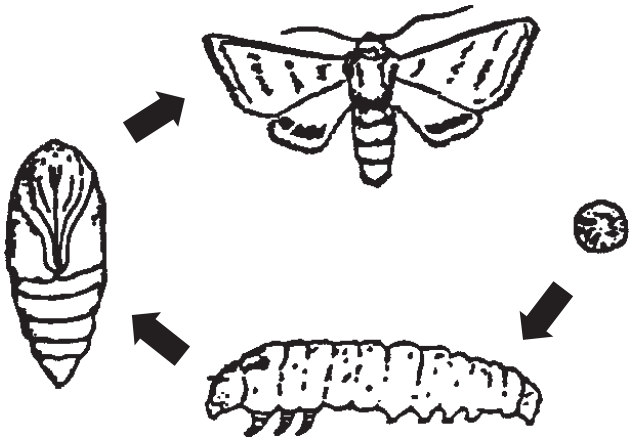


Fig. 5. Metamorphosis of a moth.



Commercial agricultural insect pests in this order include the cherry fruit fly, walnut husk fly, onion and cabbage maggot, and carrot rust fly. Others are often disease vectors, such as mosquitoes or deerflies. Vectors can transmit such diseases as malaria.

Mosquitoes are small, slender, long-legged, frail flies. The larvae are elongate and live in water. The adult female is the injurious stage. She feeds by sucking human and livestock blood by piercing the skin with her long stiletto-like mouthparts.

1. Adults have only one pair of wings and are rather soft-bodied and hairy.
2. Adults have sponging (house fly) or piercing (mosquito) mouthparts.
3. Diptera larvae may have mouth hooks or chewing mouthparts.
4. Most larvae are legless.
5. The larvae of advanced forms, such as the house fly and relatives, have no head capsule, possess mouth hooks, and are called maggots. Lower forms such as mosquito larvae and relatives have a head capsule.
6. Diptera undergo complete metamorphosis as in Fig. 6.

D. Bees, Wasps, Ants, Sawflies, etc.—Hymenoptera

This group is a large one. Many of its members are important pollinators of agricultural crops, such as the honeybee, leafcutter bee, and alkali bee. Some are important predators, parasites, and scavengers; others are injurious to humans and their crops.

1. Pear slug—The adult is black with yellow markings. The larva is small, slug-like, and feeds on leaves of pear, cherry, and plum.
2. Yellowjackets—The adults have black and yellow markings. They build nests in the ground, or papery structures on trees or under eaves. Their stings are painful and dangerous if you are allergic to them. Many species are beneficial predators.
3. Leafcutting bees—These are small- to medium-sized bees, variable in color. They are noted for their long tongues. One species is an excellent alfalfa pollinator. Leafcutters may defoliate some trees and shrubs.
4. Common ants—Several ants, such as the carpenter ants and the house ants (including the pavement ant and odorous house ant), are in this group. Many are beneficial predators or decomposers.
   a. The adults have two pairs of membranous wings.
   b. The adults generally have chewing mouthparts.
   c. The adults are rather soft-bodied or have slightly hardened bodies.
   d. The larvae have no legs (wasps, bees, ants) or have legs on the thorax and the abdomen (some sawflies).
5. Hymenoptera undergo complete metamorphosis as in Fig. 7.

E. True Bugs—Hemiptera

Consperse stink bug—A gray or brownish plant bug that is shield shaped. The stink bug feeds on many fruits and vegetables.

Fig. 6. Metamorphosis of a fly.

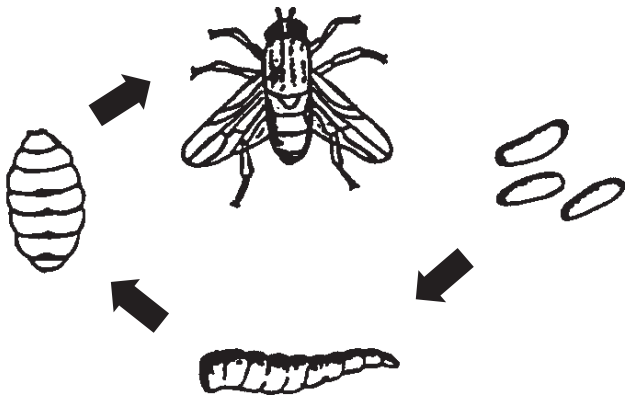
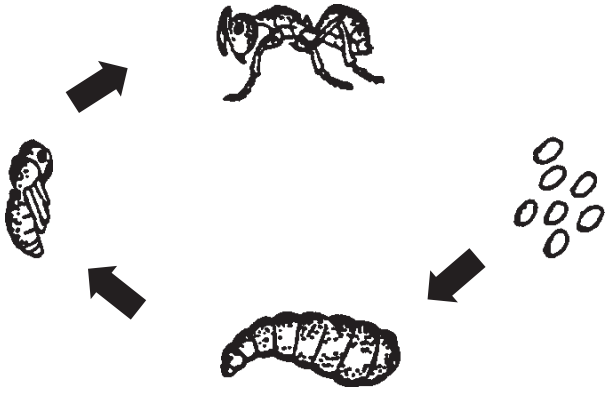


Fig. 7. Metamorphosis of an ant.



1. Boxelder bug—This bug is gray-brown to black with red lines on the under surface and on the lower portion of the outer wings. It feeds primarily on boxelder and can invade homes in early summer or fall.
2. Lygus bug—These bugs are greenish, or brownish black and occasionally yellowish or gray; they are rather slim plant bugs about 1/4-inch long. The head is blotched with black. They are probably the most injurious bugs of seed crops in the United States.
   a. The adults have two pairs of wings; the second pair is membranous, the first pair is membranous and thickened on the basal half. The nymphs are not fully formed and are called "wing pads."
   b. Adults and nymphs usually resemble one another.
   c. True bugs have piercing-sucking mouthparts.
   d. Adults and nymphs both are damaging stages.
   e. True bugs have a gradual metamorphosis (Fig. 8). The stages are egg, nymph, and adult.

F. Aphids, Scales, Leafhoppers, Cicadas—Homoptera
   1. Aphid—There are many types, sizes, and shapes of aphids. The giant willow aphid is a large, black species. The pea aphid is a rather large, green species found on alfalfa, peas, clover, sweet clover, and other herbaceous legumes. It may also be pinkish in color. Several species of aphids attack vegetable and tree crops, including the green peach aphid, which carries the leaf roll virus of potatoes and sugarbeets. The rose aphid, both green and brown forms, are found on many ornamentals. Apple aphids, and green, rosy, and woolly aphids all cause severe damage to apples.
   2. Scales—Scale insects are usually quite small and are usually circular or football-shaped. During most of their life cycle, they are protected by a hardened scale covering. San Jose scale is a pest of many fruit trees and ornamentals. Oyster shell scale is a brown cornucopia-shaped scale (horn of plenty) found on ornamental trees and shrubs. Lecanium scale is a large, brown, hemispherical-shaped scale found on trees and woody plants of several types.
      a. These insects are generally small and soft-bodied, though cicadas are larger and hard-bodied.
      b. Members may be winged or wingless.
      c. All stages have sucking mouthparts.
      d. Many members are carriers of plant pathogens.
      e. Homopterans have a gradual metamorphosis as the aphid in Fig. 9.

G. Grasshoppers, Crickets, Cockroaches, Camel Crickets—Orthoptera

   Some examples of grasshoppers and their allies are migratory and two-striped grasshoppers and the red-legged grasshopper. These are damaging pests of crops and rangeland. The camel cricket, the Jerusalem cricket, and the German roach are also commonly encountered. Crickets also can damage crops. The German cockroach is a metropolitan pest.
   1. Adults are moderate to large and are often rather hard-bodied.

Fig. 8. Metamorphosis of a bug.

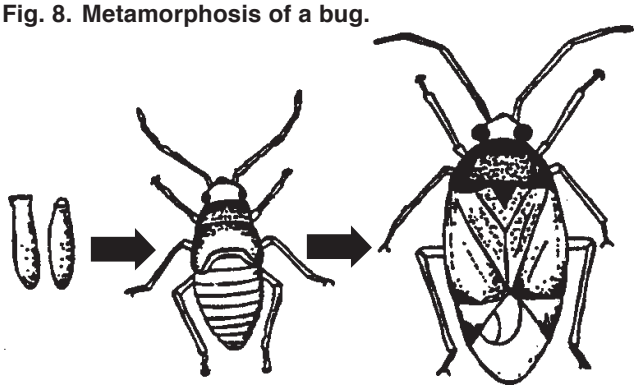


Fig. 9. Metamorphosis of an aphid.

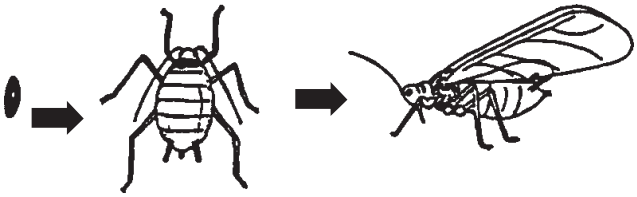
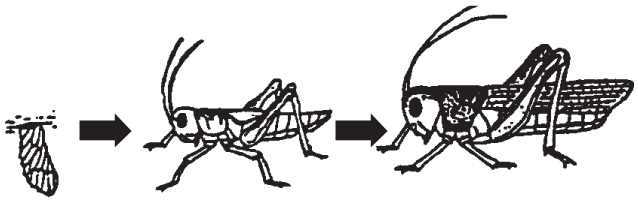


Fig. 10. Metamorphosis of a grasshopper.



2. Adults usually have two pairs of wings. The forewings are elongated, narrow, and leathery; the second pair of wings are membranous with an extensive folded area.
3. Adults and nymphs have chewing mouthparts and are damaging.
4. The hind legs of forms other than cockroaches and walking sticks are enlarged for jumping.
5. Immature stages are called nymphs and, except for being wingless, resemble adults.
6. Orthopterans have a simple metamorphosis as in Fig. 10.

H. Termites—Isoptera

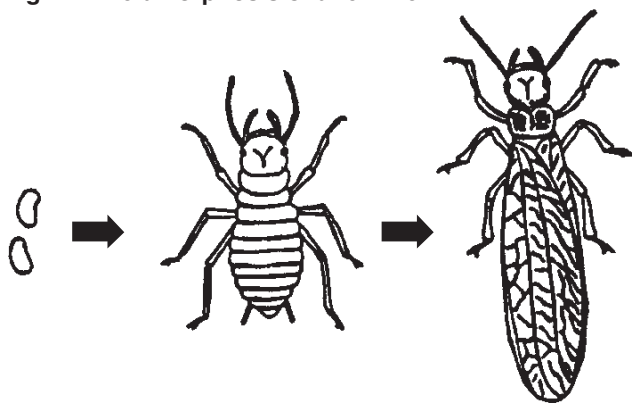
The injurious termites are generally placed in two groups: the dampwood and subterranean types. Both feed on wood and wood products. The dampwood types are usually not primary feeders on sound wood in buildings, while the subterranean types are found in large numbers in sound structures where they may do considerable damage if not detected early and controlled quickly. Colonies of the subterranean type must have a connection with soil to obtain moisture.

1. These are so-called "white ants."
2. Termites are distinguished from true ants by their thick "waists" and their white or light brown color.
3. Termites have thin, straight antennae; ants have elbowed antennae.
4. Termites have chewing mouthparts.
5. They possess many forms or castes such a worker, soldier, and queen.
6. Termites have a gradual metamorphosis as in Fig. 11.

I. Earwigs—Dermaptera

The European earwig is our only species of earwig. It is occasionally a pest of gardens,

Fig. 11. Metamorphosis of a termite.



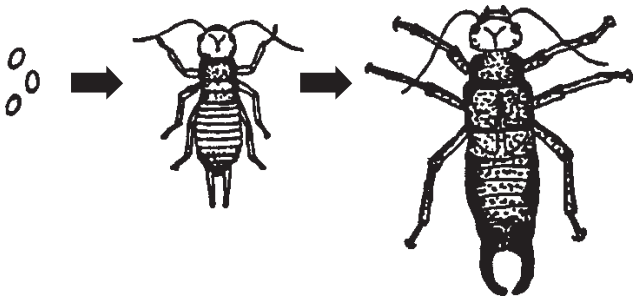
ornamentals, small trees, and houses throughout the state of Idaho, but it may also be beneficial since it often preys upon other insects.

1. Adults are moderately sized.
2. They have chewing mouthparts.
3. Earwigs are elongated, flattened and have strong, movable forceps on the rear end.
4. They have short, hardened outer wings and cover folded, membranous inner wings.
5. Earwigs have a gradual metamorphosis (Fig. 12).

J. Thrips—Thysanoptera

1. Thrips are small with sucking mouthparts that are assisted by a single mandible that aids in rasping the plant tissue.
2. Wings may be present or absent. If present, they are long and narrow and fringed with long hairs.
3. Many feed on ornamentals and some on vegetable crops such as peas and onions. Many are predators on other insects. A few species bite humans.
4. Thrips have a gradual metamorphosis.

Fig. 12. Metamorphosis of an earwig.



K. Silverfish and Firebrats—Thysanura

1. Group members have chewing mouthparts.
2. Thysanura is one of the few insect orders whose members do not possess wings.
3. These insects have bristles on the tip of the abdomen.
4. They are household pests and feed on such items as paste, paper, and crumbs.
5. They have a gradual metamorphosis.

L. Springtails—Collembolla

1. Springtails are minute insects with chewing or piercing mouthparts.
2. They possess an appendage on their ventral (under) side; it operates as a spring to aid the insect in quick escape.
3. These insects are abundant in moist areas, hence the reference to "moving piles of soot" in backyards during the wetter seasons.
4. They feed on decaying organic material primarily but will on occasion attack plants, particularly in greenhouses.
5. Springtails undergo a gradual metamorphosis.

M. Other Orders

Many other insect orders are of no real concern in the home garden. Some of the more common ones are stoneflies—Plecoptera; caddisflies—Trichoptera; dragonflies and damsel flies—Odonata; and mayflies—Ephemeroptera. These orders are all associated with aquatic habitats.

Some others you should be aware of include the nerve-winged insects—Neuroptera, many of which are beneficial predators; book or bark lice—Psocoptera, basically scavengers, but with some species that are stored-products pests; animal lice and sucking lice—Anaplura; and chewing lice—Mallophaga.

VI. Other Insect-Like Creatures

Several noninsect pests may be found in the field and home and include those listed in Table 2.

A. Spider Mites, Spiders, Ticks, and Scorpions—Arachnida

1. Spider mites—These tiny, soft-bodied animals have two body regions, thick waists, four pairs of legs, and are without antennae. Common species include the following.
   a. The two-spotted spider mite and its near relatives, the Pacific, Atlantic, and McDaniel spider mites. These mites have two spots on the back and have tail-end spots in some species. They may be clear, green, orange, or red. They are usually hard to observe without a hand lens.
   b. European red mite: This mite is carmine red with white spines.
   c. Brown mite and the clover mite: These mites are brownish or grayish, flat, and have very long front legs.
2. Spiders—Spiders resemble mites except that most are larger and the two body regions are more clearly distinct from one another (thin waist). Most spiders are beneficial predators. Common pest species include:

Table 2. Noninsect pests.

Class	Example	Description
Arachnida	Spiders, ticks, mites, scorpions	4 pairs legs; 2 body regions—cephalothorax and abdomen; no antennae; chewing or sucking mouthparts
Chilopoda	Centipedes	15 or more pairs of legs with only 1 pair of legs per body segment; 1 pair of antennae; 2 body regions—head and trunk; body flattened; chewing mouthparts; fast moving
Diplopoda	Millipedes	2 pairs of legs per apparent body segment; 1 pair of antennae; 2 body regions—head, trunk; body rounded; chewing mouthparts; slow moving
Crustacea	Sowbugs, pillbugs	1 pair of legs per body segment; 1 pair of antennae; 2 body regions—head and trunk; chewing mouthparts; roll into ball when disturbed
Symphla	Symphylan, garden centipede	11 or 12 pairs of short legs; centipedelike animals

a. Black widow spider: Shy and likes dank, dark places. This spider spins a characteristically messy web. It is normally a shiny black, moderately sized spider with a reddish or orange hourglass marking on the underside of the abdomen. Males and immature females can have stripes of red, yellow, and black on the abdomen.

b. The hobo spider, sometimes called the aggressive house spider: Is a common light brown spider that is often found in basements. This spider has a painless bite, but sometimes the skin sloughs off in the bite area.

c. The brown recluse spider: A poisonous spider which, fortunately, does not occur in the Pacific Northwest, however, it is a potential threat. It is often confused with harmless wolf spiders and other hunting spiders. The brown recluse spider can be recognized easily by a distinct, brown "fiddle case" on a light brown or grayish background.

3. Ticks—Ticks resemble large mites and are important in agriculture and medicine. They are parasites of humans and animals.

B. Millipedes—Diploda

Millipedes are generally inoffensive creatures that feed on fungi and decaying plant material. At times, they can be fairly destructive to vegetables or other plants in greenhouses. They are elongate invertebrates with two visible body regions: a head and a body. They generally are rounded in cross section. With the exception of the first four or five segments, all of the body segments possess two pairs of legs. They are relatively slow moving.

C. Centipedes—Chilopoda

Centipedes strongly resemble millipedes. They are different in that they have longer antennae, are flattened in cross section, have only one pair of legs on each body segment, and move rapidly. They are beneficial because they prey on other arthropods.

D. Sowbugs and Pillbugs—Crustacea

Sowbugs are highly dependent on moisture, which accounts for their common association with damp habitats. Generally, they feed on decaying plant material, but they will attack young plants in greenhouses and gardens. They are oval with a hard convex outer shell made up of a number of plates.

E. Garden Centipede or Symphylan—Symphla

Members of this group resemble tiny centipedes. Generally, they are a pest of vegetables and found in damp soils rich in organic matter.

Further Reading

CDs, Booklets, and Pamphlets

University of Idaho Extension

PNW 343	Beneficial Organisms Associated with Pacific Northwest Crops
PNW 186	Cockroaches
PNW 550	Encouraging Beneficial Insects in Your Garden
CD 1	Identification Keys for Insect Pests in Pacific Northwest Field Crops (CD-ROM)
MS 109	Keys to Damaging Stages of Insects Commonly Attacking Field Crops in the Pacific Northwest
CIS 414	Spiders and Their Relatives

Published 1993.

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Chapter 11
Insect Management

Vickie J. Parker-Clark, Former District I Extension Director, Coeur d'Alene

I. Terms and Definitions

A. **Insecticide**—A chemical used to control, repel, suppress, or kill insects.

B. **Preharvest Interval**—The amount of time that must elapse (legally) after application of pesticide before harvest takes place.

II. Why Worry About Insect Control?

A. The average insect population per square mile is estimated to be equal to the world human population.

B. Destruction of crops by insects in the United States ranges from $4 billion to $15 billion annually.

C. Forest insects destroy more useful timber than do forest fires.

D. Termites consume about $100 million worth of wood structures annually.

III. Methods of Insect Control Available to Homeowners

A. Mechanical Insect Control

1. Can be used on all insect pests.
2. Manual removal of insects and eggs from infested plants.
   a. Two-block method: Place the insect on one block (wood or stone) and strike with second block. Repeat as needed.
   b. A soap and water spray (or water alone) is sometimes helpful for control of aphids and similar insects.
   c. Light traps: Be careful not to use lights that may attract insects to your garden.
3. Advantages—Extremely selective; can be slightly to extremely effective, depending upon the species of insect and the crop.
4. Disadvantages—Time consuming. Many insect species can fly away or drop to the ground and therefore escape control efforts.

B. Chemical Insect Control

1. Specific insecticides control only certain insect species. It is important to know the target species and the crop affected before selecting an insecticide.
2. It is particularly important to apply the insecticide properly. This includes carefully measuring the chemical, carefully diluting the solution with the correct amount of water, and taking care not to apply too much or too little spray.
3. Apply insecticides only to plant species listed on the product's label. Failure to follow label directions may result in damage to desirable plants or unhealthy residues in foods.
4. Always determine the safe preharvest interval for a crop you plan to spray with a given insecticide. This information can be found in one of two written formats on pesticide labels.
   a. Written out on a pesticide label. For example, Ortho Sevin 5 Dust states that the product should not be applied to cole crops within 3 days of harvest.
   b. Written as a number between parentheses immediately after the crop listing on the label. For example, Lilly Miller Fruit and Berry Insect Spray has the listing Apples (7), indicating a preharvest interval for apples of 7 days.
5. Always read and follow label directions carefully.

6. Advantages—Good to excellent control of insect pests; a minimum of labor is required.
7. Disadvantages—Special application equipment needed; spray programs are often rather inflexible regarding harvest times; beneficial insects often are killed.

C. Biological Insect Control

1. Use of beneficial insects can be difficult to assess for the homeowner. Many insects are offered for sale (particularly ladybird beetles, lacewings, and praying mantids), but success with these introduced predators is often inconsistent. Also, these insects may have to be reintroduced each year in order to maintain a garden's population after winter kill or migration.
2. It is a good idea to be able to identify beneficial insect species in all their growth stages, so as to prevent their unintentional destruction as pests.
3. Advantages—No labor is involved; after the initial release, the population can be self-perpetuating. You can establish biological control, as the predator will target only the pest. For example, *Bacillis thuringiensis* is useful for caterpillars.
4. Disadvantages—Only selected insect species will be controlled; control may often be cyclical or incomplete.

D. Cultural Insect Control

1. For homeowners, the most important cultural control is to maintain good plant health with proper care through an effective water and nutrition system. A healthy plant is better able to withstand insect infestations.
2. Crop rotation breaks plant/insect pest relationships. By varying the location of crops within a garden (when possible), or by not growing certain crop types for a number of years, certain insect pest populations can be drastically reduced.
3. Highly organic soils provide attractive habitat for many soil insects. In addition, insecticides are more rapidly broken down in these soils.
4. Companion crops are often used to repel insect pests, or to attract them away from crops. Don't rely on these methods without constant observation. If they do not work, be prepared to spray, plow, dig up, etc.
   a. Repellent crops are specific as to which plants they protect and which insects they affect. For example, marigolds are useful in repelling cutworms. At best they can be marginally effective; at worst, they will attract unwanted insects to your garden.

Note: Marigolds often attract leafminer butterflies.

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   b. Trap crops can quickly become overrun with insects. For example, nasturtiums can attract cabbage aphids away from cole crops. If aphids are not controlled on the trap crop, they will eventually move to the crop you are trying to protect.
5. Weed and volunteer crop control prevents them from becoming an alternative food for insects, particularly before crop emergence. Weed residues can also harbor insect pests.
6. Sanitation in your lawn and garden area is very important, as many insects are attracted to, and overwinter in, plant debris or trimmings. Nonproducing vegetable plants should be removed or turned under as soon as possible after harvest to deny insect pests a "free lunch" or an overwintering site. Clear away planks, cardboard boxes, and overgrown areas; these provide an excellent habitat for pests such as slugs, sowbugs, and earwigs.
7. Resistant crop varieties are sometimes available to the homeowner, although most resistance involves plant diseases and not insects.
8. Using transplants or adjusting seeding dates to avoid emergence of the plant during peak insect populations may help reduce damage.

9. Advantages—Often simple to perform; often accomplished through other good gardening techniques.
10. Disadvantages—Generally incomplete.

E. Regulatory Insect Control (Quarantines)

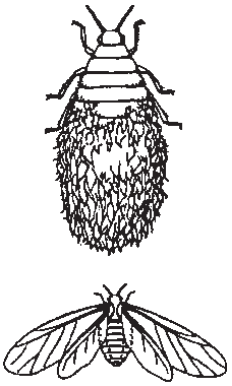
1. Generally, quarantines take two forms:
   a. No movement of the host crop allowed out of an area. This method keeps the insect more localized where control programs can be implemented more effectively.
   b. No movement of the possibly contaminated host crop is allowed into a "clean" area. This keeps the insect out of an area where infestations could be disastrous.
2. Under quarantine laws, government agencies may be allowed to use a part of chemical control under emergency use guidelines.
3. Advantage—By requiring a control effort, the spread of certain pestiferous insects can be slowed, once infestation is identified.
4. Disadvantages—Laws must be enforced to do any good and geographical situations may limit control.

F. Integrated Insect Control

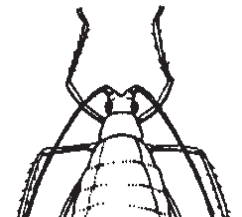
1. The best insect control plans start with the simpler methods, then progress to include aspects from all types of control. For example, a control program for the cabbage maggot may begin with transplants. This approach allows older, more vigorous seedlings to escape infestation.
2. Transplanting is followed by the destruction of plants immediately upon harvest of cole crops. Quick destruction after harvest prevents maggots from completing their life cycle.
3. If cabbage maggots continue to be troublesome, placement of lorsban or Diazinon granules around transplants may be attempted. This method prevents infestation of roots.
4. If maggots still remain a problem, it may be necessary to stop growing cole crops for a season or two or to only grow them every other year. Allowing the field to lie fallow, or switching to another sort of crop, may reduce the population of cabbage maggots in the garden.

IV. Specific Pests

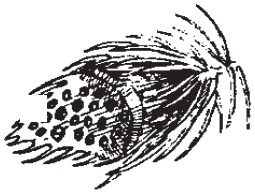
A. Ornamental Pests



1. Balsam woolly adelgid—Appear as white, woolly masses on limbs and trunks of all firs. All active stages have sucking mouthparts and cause damage. Spray timing is important. Spray to ensure adequate control. Sprays may stunt or kill trees. Organic phosphate aphid pesticides do not adequately control adelgids.



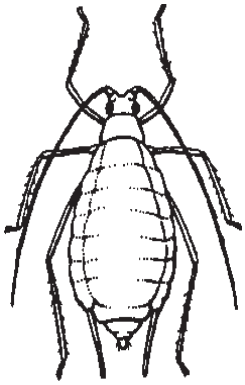
2. Spruce aphids—These aphids are dull green with sucking mouthparts. All active stages damage spruce trees, and the damage is frequently very serious. For example, they can cause severe needle drop. Spray in February or late winter.



3. Cooley spruce gall adelgid—Appear as white, cottony masses on firs. They have sucking mouthparts, and all stages cause damage. They tend to alternate between spruces and Douglas-fir. They cause galling on spruces and yellowing and needle distortion on both types of trees. Organic phosphate aphid pesticides do not adequately control adelgids. Treat spruce as the new growth is unfolding in the spring. Treat Douglas-fir in early spring.

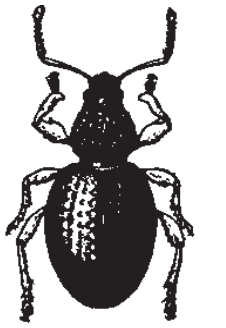


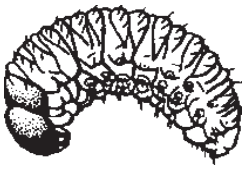
4. Rose aphid—Many species of aphids attack the rose, particularly when there is new growth. They cause chlorosis (yellowing green tissue), and they may produce a toxin that kills leaf tissue. Rose aphids excrete honeydew and cause



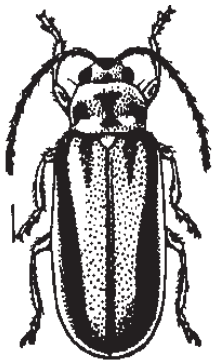
sooty molds. Some people hose plants periodically, but hosing may lead to other problems such as diseases. Check any chemicals suggested for treatment. Some may adversely affect the plant.

5. Root weevil—May be 1/4 to 1/2 inch long. They can be black, brown, or gray. They have chewing mouthparts. Root weevils often attack ornamentals, such as azaleas and rhododendrons, and many garden groups. The white larvae are C-shaped. When the larvae feed on the roots, the plant becomes spindly. Feeding allows entry by root rots. Larvae may also girdle crowns, particularly in containerized plants. Adults appear in June and feed until September. Their effect is less serious. They tend to notch leaves. Though they rarely kill the plant, the result is unsightly. They usually feed at night. Root weevils' fall migrations into homes may cause some owners alarm, but their purpose is hibernation. Spray for adults at regular intervals starting in late June.





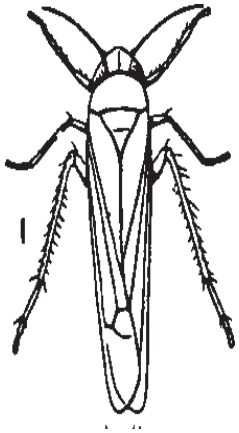
6. Elm leaf beetle—Characterized by black and yellow stripes on wing covers of the adults and bodies of the larvae. They generally appear April through August. These beetles live through two generations and may overwinter in homes. They have chewing mouthparts. Both larvae and adults cause damage to elms. The





adults chew small holes in leaves, while the larvae skeletonize leaves. They can cause complete defoliation.

Note: Destroy if found.



7. Leafhopper—Small torpedo-shaped insects with wings held roof-like over the body. Found in a variety of colors. Leafhoppers are active jumpers. They attack a variety of ornamentals, fruit trees, and garden plants, and may be found throughout the growing season. They have sucking mouthparts and feed on the undersides of leaves, which causes white speckling on leaves (hopper-burn). Leafhoppers can transmit virus diseases.





8. Cotoneaster webworm—Small, dark-brown to black caterpillars are the damaging stage. They have chewing mouthparts and hide in dense webs. They tend to skeletonize cotoneaster leaves and can kill or severely damage plants.





9. Fall webworm—Adults are pure white moths, though they occasionally have a few black spots. The larvae are yellowish brown with long, whitish hairs arising from orange and black bumps. They can be identified quickly because they form unsightly tents enclosing entire branches. The chewing mouthparts are damaging. Webworms tend to cause problems only as larvae, and primarily for ornamentals and

fruit trees. The larvae are present from midsummer to fall. Treatment is a problem, because if you remove and burn the branch and the tent, you may destroy the symmetry of the shrub or tree.

10. Juniper webworm—The larvae are light brown with dark brown stripes on the back; they grow to a length of 1/2 inch. The larval stage is the most damaging. Larvae have chewing mouthparts, and they tend to attack junipers and red cedar. They feed in early spring. Webworms can be identified easily because they web the foliage together. Mechanically destroy the larvae when possible.



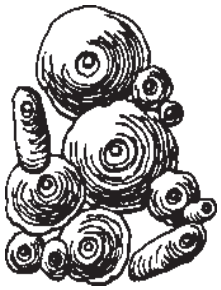


11. Mourning cloak butterfly—Larvae are large and black with orange spots on their spiny backs. The larval stage is the most damaging. Larvae attack willow, elm, and poplar. They are foliage feeders with chewing mouthparts. These caterpillars are gregarious feeders and are easily controlled by clipping twigs with groups of caterpillars. Simply burn the clippings. Spraying is not necessary if the problem is caught early enough.

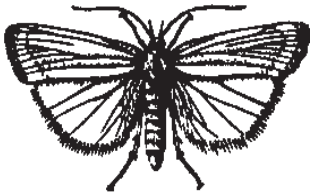


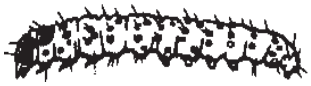


12. Tent caterpillars—The larvae are rather attractive, dark, fuzzy caterpillars. The forest tent caterpillar has diamond- or keyhole-shaped spots in a row along the back. The western tent caterpillar is yellow with blue lines. Tent caterpillars congregate in small tents during the day. The larval stage is the damaging stage, seriously defoliating trees of many kinds. Larvae have chewing mouthparts. Tent caterpillars are troublesome in early spring and into summer. Sometimes you can deal with them by clipping tents and by burning. Forest tent caterpillars overwinter as eggs in bands around twigs. Destroy these by crushing them. Or you can spray in early spring; later they may be tough to kill with chemicals.
13. Birch leafminer—Only the larvae of the birch leafminer are damaging. They mine and blotch the leaves of birch trees. They have chewing mouthparts. To deal with them, spray just after the leaves unfold in the spring. There are two generations. The second is in mid-July, but if you do a good control job on the first, the second will need only a minor use of spray to control.
14. Scales—Scales are small, with a soft or hard coat surrounding the insect. The covering takes on various forms from hardened armor to soft, cottony masses. They often promote sooty molds, and all active stages are damaging to many plants. They have sucking mouthparts and are stationary (sedentary) feeders. They kill plants or plant parts. In order to treat, find out what scale is present and at what time the active crawling stage is present. Spraying with an insecticide will be effective at that stage. Oil and sulfur dormant sprays are usually the most effective.



B. Lawn Pests
    1. Lawn moths—Damage may be mistaken for thatch or fungus problems. The larval stage is the most damaging. Lawn moths have chewing mouthparts.



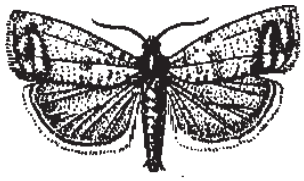


2. Earthworms, nightcrawlers—These are not insects, but annelids. They are normally considered to be beneficial; however, in certain instances, intense earthworm activity leads to castings being thrown up on the surface, leaving an unsightly lawn.

C. Houseplant Pests

See Chapter 23, "House-plants and Home Greenhouses," Section V, Insect Pests.

D. Tree Fruit Pests





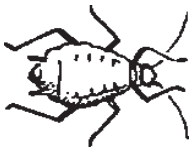
1. Codling moth—The larvae have chewing mouthparts and bore into fruit. Apples and pears are the main hosts. The larval stage is the most damaging. It is extremely important to time sprays properly. Use recommended materials about 10 days after full petal fall and repeat as necessary, depending on materials used and local recommendations.



2. Aphid (woolly apple aphid)—These are reddish aphids are covered by white woolly wax. They have sucking mouthparts. All active stages are damaging. These aphids are bark feeders, and their damage interferes with the growth of the tree, often killing a young tree. They also attack roots. Their attacks cause the most serious injury in apple trees, but occasionally they are problems for pear trees.



3. Aphid (not woolly species—They have sucking mouthparts, and all active stages cause damage. They include the green peach, plum, rosy apple, and green apple aphids. A toxin in the saliva causes various



plant reactions: leaf curl, leaf cupping, stunting, lumpy fruit, etc.



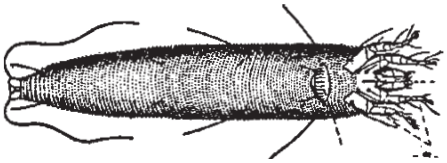
4. Apple-and-thorn skeletonizer—The larval stage is the damaging stage; the larva has chewing mouthparts and skeletonizes leaves. The adult stage is a moth.





5. Fruit leafrollers—The larval stage is the most damaging. Larvae are usually shiny green with a black or brown head. They have chewing mouthparts and feed on the fruit and the leaves of many ornamentals and fruit trees. They tend to bind leaves together with a webbing to form a hiding place.

6. Blister mite—Blister mites are arachnids, not insects. They have chewing mouthparts. The only evidence of their presence is the circular blisters within which these tiny microscopic mites reside. They may become so numerous as to cover an entire



tree. Young shoots suffer the most. Blister mites cause malformation of pear fruit; they also attack apple and cotoneaster trees. The blistered surfaces later turn into scablike areas. They are best controlled during the delayed-dormant period (February or March).

7. Pear psylla—Related to aphids and leafhoppers, pear psylla have sucking mouthparts. Feeding is done by all active stages. The pear psylla secretes honeydew, which may kill leaf tissue and which russets fruit. A sooty mold devel-

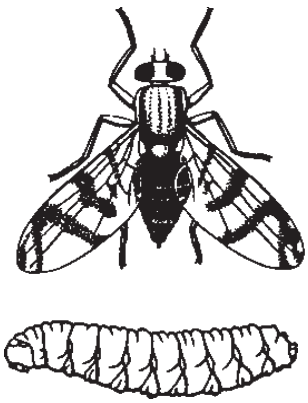


ops in honeydew and blackens affected tissue, which leads to "pear decline." Other problems from psylla include reduced vigor, fruit loss, poor fruit set, and occasionally the death of the tree.

8. Pear slug—A relative of the sawfly bee group, several species of the pear slug are known. The larvae are covered with a slimy material, making them sluglike in appearance. The larval stage is the most damaging. Pear slugs have chewing mouthparts that skeletonize the leaves. Pears, cherries, and roses are hosts commonly attacked by the pear slug or one of its relatives.



9. Cherry fruit fly—The larval stage is the most damaging; the larvae have rasping mouthparts. The adult is a small picture-winged fly. Eggs are laid in fruit starting when the fruit changes to pink or yellow (depending upon the variety). The larvae proceed to feed internally. Breathing holes in fruit point out the presence of the maggots.



10. Walnut husk fly—The larval stage is the most damaging. Larvae attack mainly walnuts, but occasionally attack late peach varieties. The adult is a picture-winged fly. In walnut trees the damage to the husk results in the staining of shells and, at times, the darkening of the kernels. Bitter, shriveled kernels may occur.







11. Peach tree borer—The adult is a clear-winged moth. The larvae are damaging to peaches, nectarines, and plums. Larvae have chewing mouthparts. Their injuries are recognized by jellylike gum mixed with dirt and small pellets of frass excreted by the borers at ground level. This damage can seriously injure a tree or even kill it. Heavily infested trees are so devitalized that the leaves turn yellow in a manner similar to nitrogen deficiency.
12. Peach twig borer—The adult is a small, gray moth. The damaging larvae are light- to dark-reddish brown with a black head and yellow-white, ringlike segments around the abdomen. Larvae have chewing mouthparts. They attack developing twigs and burrow down the tender shoots, causing them to wilt and die. Later broods attack fruits. The oriental fruit moth causes similar damage, but is not as widespread in Idaho.





E. Garden Pests

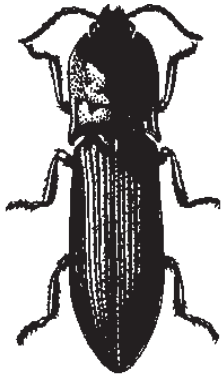
1. Cutworms—The adult is a miller moth. The larvae have chewing mouthparts and are the most damaging stage for garden produce. Many kinds of cutworms exist



and damage all kinds of plants. Control with chemicals when they are young. The more mature cutworms are difficult to control with chemicals. If cutworms have been a problem, vigorous disking or rototilling in the spring, before planting, will help destroy them. Also avoid persistent weed patches as this is a good source of cutworms.

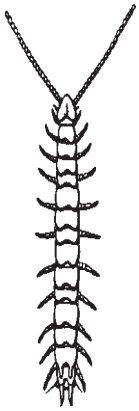


2. Wireworms—Have rather hard, shiny, golden colored, elongated larvae. The adult stage is a click beetle. The larval stage is the most damaging. Wireworms have chewing mouthparts. They are a soil pest; their feeding stunts crops. They may kill the plant or cause produce to be inedible. Potatoes and bulb crops are particularly hard hit by this pest; however, corn and other crops may be damaged.

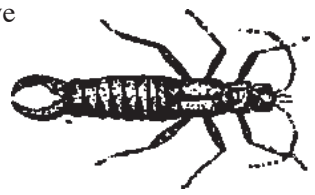


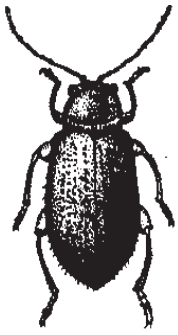


3. Garden symphylan (insect relative)—These are soil pests with chewing mouthparts; they tend to attack underground parts of all vegetables, small fruits, and many flowers. All stages of the garden symphylan are damaging; infestations are sporadic. Control of this pest is difficult for the home gardener. When the attack is severe, plants wilt and die.

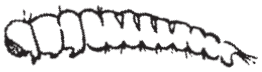


4. Earwigs—Often merely a nuisance, though all active stages cause damage. Earwigs have chewing mouthparts and attack many sorts of plants. They can be scavengers or predators also. The best control methods are various dusts. Apply dust recommended in your area to soil surfaces when you first notice the problem. Repeat if necessary.

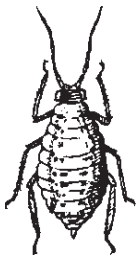




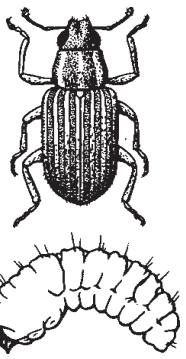
5. Flea beetles—There are several species of flea beetles, all of which have chewing mouthparts. Both the larvae and the adults cause damage. The adults attack leaves of many vegetables. The larvae attack roots and tubers. The adults are very tiny beetles and, like fleas, are good jumpers. Use chemical control if necessary.



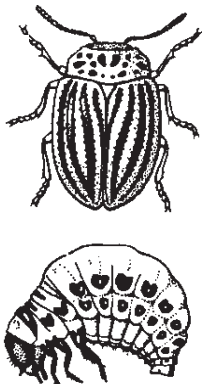
6. Aphid—All active stages cause damage. The peach aphid is one of the most important aphids. It affects not only peaches but also potatoes. It is a vector of the potato leaf roll virus, which discolors tubers. The asparagus aphid is also becoming important.



7. Pea leaf weevil—The adult is the damaging stage. The larvae feed on root nodules of peas. Pea leaf weevils have chewing mouthparts. While peas are the preferred host, this weevil will attack other plants such as beans.



8. Colorado potato beetle—Although mainly a pest of potatoes, Colorado potato beetles can feed on tomato, eggplant, and nightshade weeds when potatoes aren't available. Both the larvae and the adults are damaging. These beetles have chewing mouthparts.

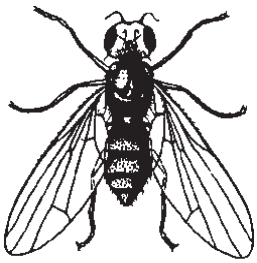




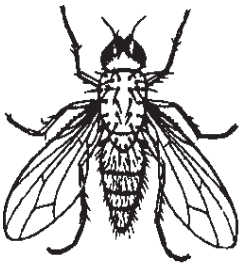


9. Asparagus beetle—Rather small beetles with chewing mouthparts, asparagus beetles are steel blue in color with reddish margins and a few yellowish spots on wing covers. Larvae and adults damage young shoots, but they are chiefly a pest of mature plants, which may be completely defoliated.

Note: The spotted asparagus beetle is somewhat elongated and red-orange with black spots.

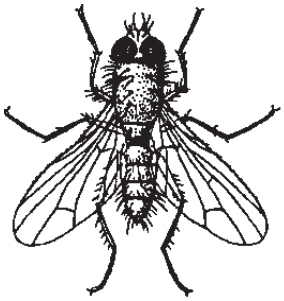


10. Carrot rust fly—The larvae have rasping mouthparts. The larval stage is the damaging one. The adult is a small, nondescript fly, while the larvae are small maggots that burrow into the crowns or roots of carrots, parsnips, and certain weeds. Only highly organic or humus soils harbor this insect. Remove carrots as soon as possible, since the damage will increase if they are left in the ground. A diazinon application will reduce, but not eliminate, the carrot rust fly. However, mid- to late-June plantings tend to reduce damage.



11. Onion maggot—The adult is a fly. The larval stage is the most damaging. Larvae cause damage with their rasping mouthparts and create problems similar to those caused by the cabbage maggot, except that onion maggots attack only onions, garlic, and shallots.







12. Cabbage maggot—The adult is a fly. The larval stage is the most damaging. The larvae are small, whitish maggots with rasping mouthparts; they bore into roots and stems of cabbage, broccoli, cauliflower, brussel sprouts, and kale, often killing them. The fleshy roots of radish and turnips may be riddled with holes. Control consists of diazinon or chlorpyriphos (dursban) treatments at the time of transplant or planting.

Note: Be careful. Highly organic or humus soils tend to tie up insecticides such as diazinon and dursban.

13. Cabbage looper—The adult is a moth. The larvae have chewing mouthparts. They attack many cruciferous plants, as well as fruits, weeds, and ornamentals. They are defoliators.





F. Household Pests

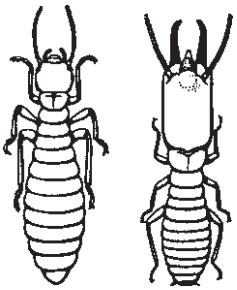
1. Stored products.
   a. Many pests go after stored products. They include the carpet beetle, cigarette beetle or drugstore beetle, Indian meal moth, sawtooth grain beetle, and cockroach. Sanitation is the best control.
   b. Locate the pest sources and clean them out thoroughly. Destroy infested material or heat to 140°F. Vacuum infested drawers and cupboards.

c. Spray with pyrethrum in and around possible hiding places, but not on or around food.

d. Maintain a regular spring cleaning program.

2. Structural pests.

a. Termites: These pests are antlike, but they do not have constricted waists. They usually attack only damp or rotting wood and are an indication of an already existing problem. It is important to treat these pests properly. When carpenter ant or subterranean termite infestations are apparent, it would be wise to contact a reputable PCO (exterminator) to kill these damp wood termites.



b. Ants: The most common ant pests are carpenter ants.



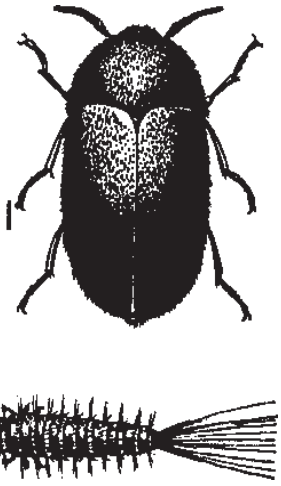
Carpenter ant

3. Nuisance pests.

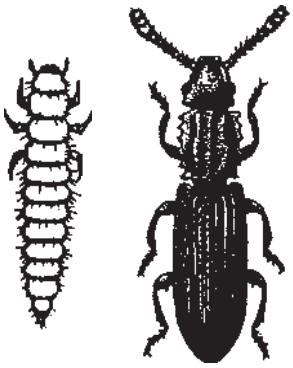
a. Flies: Flies are common, especially in the summer and the fall. Tight seals around windows and screen doors help. It also helps to maintain general cleanliness, as fly larvae can breed in any kind of refuse. Keep garbage containers clean. Pyrethrum sprays will kill the adults.

b. Mites: Many mite species, including the clover mite, enter homes in large numbers, causing the inhabitants great alarm. Some scavenging mites, such as grain mites, can get into stored foods. House dust mites can be a source of allergies.

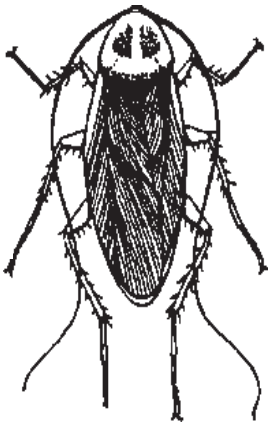
c. Centipedes and millipedes: Though centipedes are normally beneficial, these elongated, multilegged insect relatives often enter homes and cause annoyance. Centipedes can inflict painful bites, while millipedes can become pests in greenhouses.



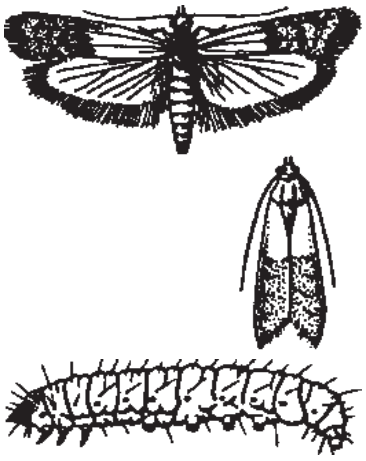
Carpet beetle



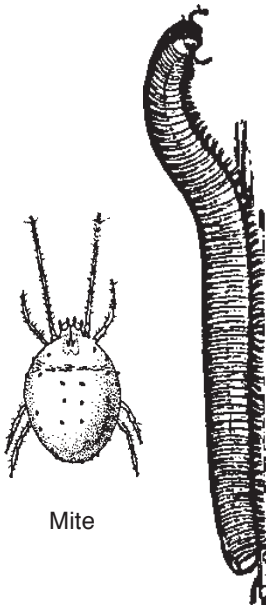
Sawtoothed grain beetle



Cockroach



Indian meal moth



Mite

Millipede



Centipede

d. Other: Careful calking, screening, and patching will prevent many problems with wasps, bats, and other home invaders. Many true bugs such as boxelder bug, sage bug, grass bug, and others will invade homes and other structures in the late summer and fall. While they're capable of biting, the true bugs normally are considered nuisance pests. Several beetles are also invaders and become severe nuisance pests. Control is difficult; sweeping or vacuuming is normally recommended. These include grass weevils, root weevils, and the elmleaf beetle (overwinters in large numbers in attics).

G. Spiders

Most spiders are harmless. The black widow is the most dangerous spider in the Northwest. (The brown recluse spider has not been found in Idaho.) The hobo or "aggressive" house spider is common and can cause skin sloughing. For more information about spiders see the University of Idaho College of Agriculture CIS 414, "Spiders and Their Relatives."

Spiders can become numerous in the fall as they seek out overwintering spots. Be sure to seal up basement entries (holes, cracks).

Further Reading

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CDs, Booklets, and Pamphlets

University of Idaho Extension

PNW 343	Beneficial Organisms Associated with Pacific Northwest Crops
PNW 186	Cockroaches
CIS 603	Insect Control for Apples and Pears in the Home Orchard
CIS 605	Insect Control for Stone Fruits in the Home Orchard
CIS 834	Insects and Other Pests in Firewood
MS 109	Keys to Damaging Stages of Insects Commonly Attacking Field Crops in the Pacific Northwest
CD 1	Identification Keys for Insect Pests in Pacific Northwest Field Crops (CD-ROM)
CIS 829	Locust Borer
CIS 1133	Management of White Pine Weevil in Spruce
PNW 326	Preventing and Controlling Powderpost Beetles in and Around the Home
CIS 414	Spiders and Their Relatives

Washington State University

EB 1106	Biology and Control of Tent Caterpillars
EB 1270	Birch Leafminer
EB 1380	Bronze Birch Borer
EB 0818	Carpenter Ants: Their Biology and Control
EB 1257	Carpet Beetles
EB 1068	Cherry Fruit Flies
EB 1206	European Earwig Prevention and Control
EB 1011	European Pine Shoot Moth
EB 0827	Fall Webworm
EB 0963	Gypsy Moth
EB 0695	Houseplant Pests
EB 0936	Pine Bark Beetles
EB 0970	Root Weevil Control on Rhododendrons
EB 1485	Snailcase Bagworm
EB 1154	Western Boxelder Bug
EB 0643	Yellowjackets and Paper Wasps

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Chapter 12

RODENTS, BIRDS, AND OTHER PESTS

IDAHO MASTER GARDENER
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Chapter 12
Rodents, Birds, and Other Pests

Kevin M. Laughlin, Extension Educator, Ada County, Boise

I. Introduction

Some gardeners worry about critters while others consider them part of nature's plan. One gardener's wildlife habitat or sanctuary is another gardener's nightmare or problem.

Over the years you spend tending a garden, you come to realize there are a few shortcuts to preventing animal and other pest problems. Some you need to control; others you learn to live with; and others you learn to share with other gardeners.

In all cases, you need to consider personal pest management objectives, the environment (city or country) in which you are gardening, your neighbors, and how treatments will impact the individual plant as well as the environment.

Proper identification, timing, persistence, and diversification will play an important role in successful pest management plans.

II. Safety in Handling

Recently in Idaho, hantavirus has become a concern for anyone handling vertebrate pests. Also of concern are several other animal-human transferred diseases and parasites including rabies, plague, lyme disease, and Rocky Mountain spotted fever.

If you handle equipment and work in areas where vertebrate pests are a problem, wear or use masks, gloves, and other protective clothing when implementing control measures.

III. Identification

Gardeners often become frustrated with the diverse creatures described in this chapter. Unlike many garden pests that remain in place or move around slowly (described in other chapters), these pests are marauders, staging hit-and-run attacks on desirable plants, yards, and gardens.

To find acceptable solutions, you must accurately identify the target pest. Most creatures have predictable needs and activities, and you may be able to control or deter them by understanding their habits.

A. This chapter covers only a few of the most common pests.

B. Your best source for specific species management is the Nebraska Cooperative Extension System's *Prevention and Control of Wildlife Damage Handbook*. This resource publication covers more than 80 species.

C. You can obtain more information about specific pests from the U.S. Fish and Wildlife Service, USDA-APHIS Animal Damage Control Specialists, the Idaho Cooperative Extension System, or the State of Idaho Fish and Game Department.

D. It is unlawful in Idaho to gas, poison, shoot, trap, or otherwise harm any endangered, wild animal, or wild bird species without special permits. Hunting seasons, the Migratory Bird Act, and the Eagle Protection Act regulate other animal harvesting. Before starting a vertebrate pest management program, be sure it is legal. Check with a local game warden for any local shooting and trapping limitations.

E. Always read the labels of federal and state approved pest control products before implementing control measures. It is illegal to use any pesticide not listed on a label.

The user is responsible for checking the label to see that the site is listed.

F. Some pest-control measures are traditional or involve folklore repellents. The Cooperative Extension System does not have scientific data to support the use of most, but you may wish to try them.

IV. Vertebrate Pests—Rodents

A. General Rodent Information

Most methods used in controlling rodents are aimed at destroying them. Poisoning, shooting, exclusion, destruction of habitat, trapping, and fumigating are among the methods used. Of these, poisoning is the most popular and probably the most effective and economical. Because rodent control is a diverse and complicated subject, it is beneficial to learn the life cycle of each rodent pest as you encounter it and before management.

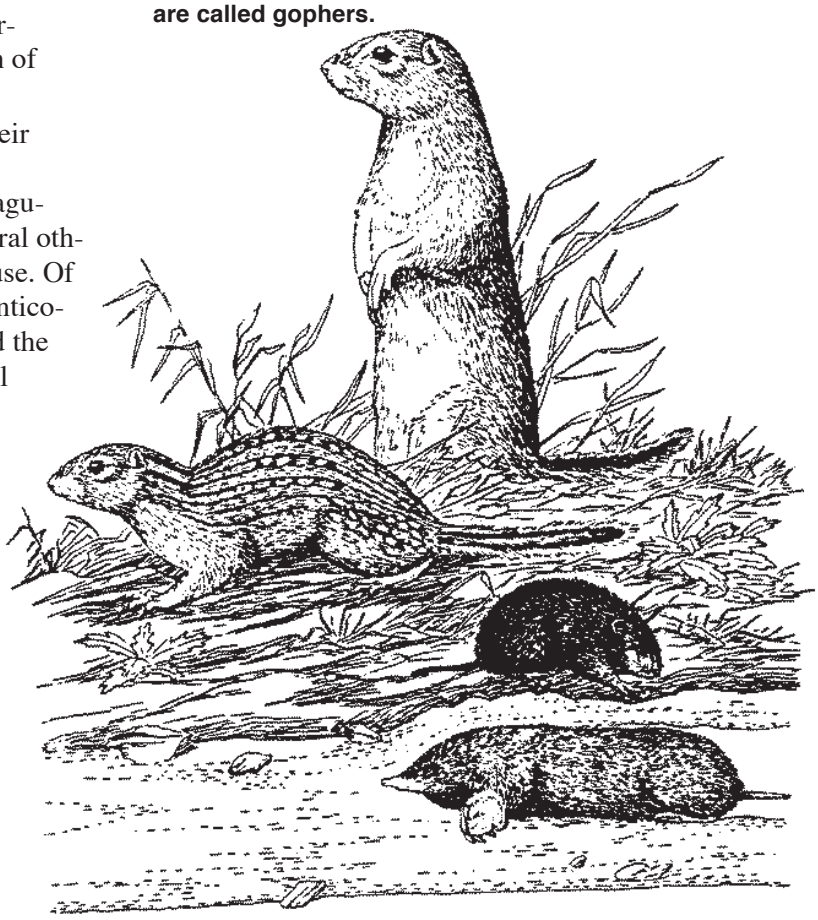
1. "Rodent" is rather all inclusive and perhaps a bit deceptive, because all rodenticides or repellents are not registered for all species. This requires accurate identification of the particular pest and careful selection of control materials.
2. Rodenticides differ widely in their chemical nature. Strychnine, indandiones, coumarins (anticoagulants), zinc phosphide, and several others are labeled for commercial use. Of the rodenticides available, the anticoagulants are safest to use around the home, provided you follow label directions and pets don't accidentally ingest them. This is a particular concern with cats that are good "mousers." Sold as baits, the animal must ingest them for several consecutive days before they are effective. Several other restricted use rodenticides are available for trained and licensed applicators. Rodent repellents Biomet-12 naphthylene, paradichlorobenzene, polybutanes, polyethylene, R-55 and thiram have been used with some success against specific rodent species.

B. Ground Squirrels, Chipmunks, and Chucks

These rodents are voracious feeders on lawns, bulbs, and leafy succulent plants during spring and summer. Ground squirrels (Fig. 1) may dig a burrow system with entrances 2 to 3 inches (5 to 8 cm) in diameter. They are particularly troublesome in gardens that border fields or wild lands.

1. The simplest removal method is to fill burrows with water. Reflooding may be necessary to keep them discouraged.
2. Also consider live traps (check daily for relocation), gas bombs (place well back in the burrow after plugging all entrances), and poison baits.
3. Protect bulb beds above ground with a cover of fine mesh chicken wire.
4. Repel rodents by placing moth balls or moth flakes in the runs or holes where they enter buildings.

Fig. 1. Sometimes, the Richardson ground squirrel (from top to bottom), the 13-lined ground squirrel, vole, and mole are called gophers.



5. Chief natural enemies are foxes, snakes, hawks, and owls. Dogs and cats also can work into the control picture.

C. Pocket Gophers and Voles

Pocket gophers burrow through the ground, feeding on root crops and roots of garden plants and do surface damage to lawns and gardens. Voles, as in Fig. 1, primarily do surface damage to grass areas and may girdle woody plants.

Gopher runways run parallel to the ground surface and are located 6 to 10 inches (15 to 25 cm) below ground level. Control is usually easiest in early spring or fall when fresh mounds indicate activity.

1. Place poison baits, fumigant type pellets, or traps in their runs. Locate the burrow with a long screwdriver or probe. Carefully follow the control product or trap label instructions. If trapping efforts fail, line the sides of planting holes with light gauge chicken wire or hardware cloth.
2. Eliminating ground cover reduces population. Soil cultivation destroys burrows and reduces cover.

D. Mice and Rats

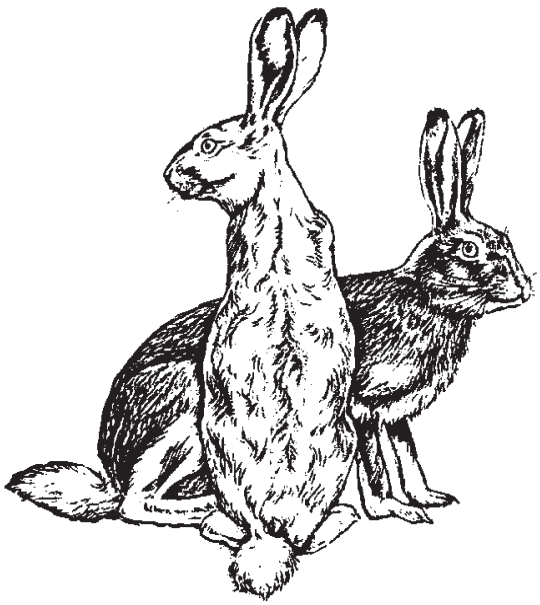
Mice or rats can spread disease and viruses, consume and contaminate stored products, and may girdle woody plants by chewing bark (particularly in the winter). Mice eat seed and grain products and grass, and create runways and bare patches on lawns. Damage to lawns can be severe in winters when snow covers the ground for months.

1. Sanitation is your first line of defense. Conduct a general cleaning, eliminate food sources, and destroy rodent nests. Get rid of rock piles, old boards, and junk. Keep piles of wood and lumber up off the ground. Mow lawns regularly and remove long grass and vegetation from adjacent areas. Keep areas around the base of trees and shrubs free of grass and loose mulch where mouse damage is a problem. Store all dried and bagged food in rodent-proof containers. Proper composting of kitchen waste is important. Keep seeds and livestock or pet food in sealed containers.
2. Diligently apply taste and smell repellents to the problem areas. Use live or spring traps or place bait boxes or poison baits where other animals and children cannot reach them. Some rats may become bait shy and others may develop an immunity to anticoagulants, so change the types and active ingredients of poisons when confronted with extended problems. Immunity develops over time and constant exposure to anticoagulants. It may be necessary to prebait. After completing sanitation measures, create bait stations. Place the baits in runways along a wall or fence where rodents often travel or places where rats or mice seek shelter. Check baits frequently to ensure they are fresh, dry, and free of mold.
3. In orchards, field mice feed on trunks of trees, rarely burrowing below ground. If the orchard is mulched, be sure to pull the mulch back a few feet from tree trunks in the fall. To deter field mice, place wire cylinders, tree collars, and plastic or paper wraps around the base of fruit trees.

E. Rabbits

Rabbits will girdle young trees, chew off bark and young twigs of woody plants in winter, and consume leafy plants during summer (Fig. 2).

Fig. 2. Cottontails and jackrabbits can become serious, year-round pests.



1. You can live trap and relocate rabbits. Reduce the rabbit habitat by removing overgrowth on ditches, bushy fence rows, or brush piles within or near garden areas. Rabbits don't like to be far from cover so mowing, brush cutting, and general clean up can help control them.
2. Place guards made of fine mesh (1/4 inch) screens around the base of trees to protect them from rabbit damage. Form the guards into cylinders about 2 inches larger than the diameter of the tree trunk and long enough to protect the tree above the snow line. Tightly woven (no larger than 1-inch mesh wire and at least 30 inches high) fences, well anchored to the ground also work well.
3. Plant "trap" crops like beans away from the garden to divert rabbits. This may provide extra food, however, resulting in more rabbits. Also, onions seem to repel rabbits, so it may help to interplant an occasional row with your crops.
4. Also effective are commercial repellents containing Thiram or Ziaram fungicides or other materials sprayed or painted on tree trunks, plants, or shrubs. Blood dust, nicotine, and other repellents are labeled for rabbit control.
5. To discourage rabbits, some gardeners sprinkle dried blood meal around plant roots or spray a cow manure and water solution to reduce interest in particular plants. Others apply powdered rock phosphate, powdered aloes, red cayenne pepper, or fish tankage with bone meal to seedlings as they emerge or as a dust on plants. Some gardeners spray or place coyote, fox, or other animal urine mixtures around garden areas as repellents.

F. Bats

Bats are beneficial insect-eating animals. Occasionally bats get into buildings or attics where they foul the area with odorous feces or guano and disturb the occupants with their nocturnal activities. Bats can carry rabies. Always vaccinate your pets. Do not handle bats. If you must handle them, wear heavy leather or rubber gloves.

1. One or two bats in a house is a problem. Usually, a bat will find its way out by detecting fresh air movement, so the simplest solution is to open windows or doors leading outside. Bats have day and nocturnal roosts that they return to daily. Each species selects roost sites with specific temperatures. If the roosting area is too hot, too cold, or too drafty, they will leave. A single light bulb in the space where they roost may keep it too hot for bats. Another solution is to create a draft by opening doors and windows and using an electric fan. To discourage bats from roosting in one place, scatter 3 to 5 pounds of moth flakes over the floor or hang them in mesh bags from the rafters.
2. The best time to bat proof a building is in the fall or winter when bats migrate to wintering areas. As soon as they leave, seal the openings in eaves and attic louvers with 1/4-inch mesh, narrowly-spaced, parallel tight-wires or fishing-line screen, or boards. Seal narrow cracks with caulking compounds. If you are bat proofing a building, be sure all bats are outside before plugging the last opening. Not all bats will leave at the same time. Consider installing a one-way device to allow bats to leave but not return. Building bat houses for excluded bats may help with the problem the next season.
3. Placing floodlights in the attic or directing them at openings for several nights will not discourage entry. Instead, the lights will attract nocturnal insects such as moths, providing a ready food source for bats.

V. Vertebrates—Other Mammals

A. Raccoon

Raccoons have become adapted to urban and suburban areas, feeding at night at "garbage can" restaurants or from pet dishes (Fig. 3).

1. Raccoons are easy to catch with box traps. Normal fencing will not keep raccoons from your garden; however, electric fencing is particularly effective.

Fig. 3. Raccoons become especially bothersome near harvest for corn, melons and other fruit.



2. Sprinkle black pepper on corn ears before they are ripe. Installing motion lights and leaving radios on in the garden at dusk and dawn may help repel raccoons.

B. Deer

Deer can damage herbaceous and woody plants by browsing (Fig. 4). Orchard and vegetable crop damage are a concern, too.

1. Base your landscaping on deer-feeding preferences to avoid using expensive chemical repellents. Planting resistant or less palatable vegetables, annuals, perennials, trees and shrubs in landscapes will discourage browsing.
2. An inexpensive way to exclude deer is to construct a wire-mesh fence, 7 to 10 feet (2 to 2-1/2 m) high, around small gardens or orchards. A horizontal outrigger—a fence extension—makes it harder for deer to jump fences. Some gardeners have had success with two parallel 5-foot fences with a 5-foot "no deer" area between them. In some areas, electric fences work if constructed with at least five wires. Tightly strung piano wire in the Australian fashion of crossbeams forming an "X" at three heights also works. Deter deer by placing welded-wire fencing around individual trees or plants or types of plants or use other mechanical devices such as rigid tubes (Vexar, Tree Shelters, and Tubex), flexible sleeves, and bud caps.

Fig. 4. To learn more about controlling deer damage and deer-resistant plantings, see the various publications in the "Further Reading" section at the end of this chapter.



3. Several commercial repellents are registered and may be partially successful. They require repeated applications, particularly after rains or watering. Spray contact or taste repellents such as Thiram, Ziram, and capsaican (derivative of chili pepper) on the lower trunks of trees and lower limbs at 2-week intervals.
4. Other methods include sport hunting to reduce populations; live traps for removal by conservation officers or professional biologists; temporary frightening devices such as gas exploders, tethered dogs, fireworks, or a radio left on at night; human hair balls or deodorant soap bars hung at close intervals around valuable plants or around the garden; and blood meal, coyote, or other animal urine sprayed or placed around garden areas as repellents.

C. Skunk

Skunks are protected by law in most states and frequently are found to carry rabies. If possible, avoid handling skunks because they can eject their scent 6 to 10 feet. The persistent odor on clothing, in gardens, or buildings is highly offensive (Fig. 5).

1. One method of control is to exclude skunks from their sleeping or nesting quarters. Sprinkle a thin layer of flour around holes or building entrance areas to form a tracking patch. Examine the area after dark, when the tracks lead out of the

entrance. Close the space off with lumber or fencing, or consider live trapping and relocating the skunk. Leaving a radio on all day in the skunk's nesting area may disturb sleep patterns enough to cause them to relocate.

2. A chemical known as Neutroleum-Alpha is probably the most effective odor neutralizer available. A tablespoon in a water bath works well for pets and humans unfortunate enough to be "hit." Use 2 ounces in each gallon of water to scrub walls, out buildings, basements, outdoor furniture, and the like. You also can use chlorine bleach or household vinegar (diluted 1 to 10 parts water) with a little detergent. Tomato juice is not as effective.

D. Dogs and Cats

Male dogs urinate and kill parts of leafy plants, especially conifers; female dogs' urine may cause dead patches in a lawn. Dogs leave feces on lawns or flower beds and dig in garden beds. Cats can severely damage bark on young trees where they sharpen their claws. They dig in garden soils and leave fecal matter that may transmit parasites or diseases to humans. Cats are the number one enemy of song birds in the garden.

1. Controls include fences; scolding; clapping hands; waving brooms; or spraying the cat or dog with water from a garden hose. A screen around the tree base will obstruct cats as will clipping the cat's claws. Cats will avoid resting or walking on walls or fences with moth crystals sprinkled at regular intervals.

Fig. 5. Skunks are kin to weasels and are not afraid of man.



2. Repellents are almost too numerous to mention including allyl isothiocyanate, amyl acetate, anethole, bittrex, bone oil, capsaican, citrus oil, cresylic acid, eucalyptus, geranium oil, lavender oil, lemongrass oil, menthol, methyl nonylketone, methyl salicylate, nicotine, pentanethiol, pryidine, sassafras oil, and thymol.

VI. Vertebrate Pests—Birds

A. General Bird Information

All birds, in one way or another, are beneficial to man. They can, however, create problems singly or in groups. Birds are important in preventing insect outbreaks and their control of other garden pests benefits most gardens. Man considers birds pests when they consume and destroy fruit and seed crops such as strawberries, sweet cherries, and sunflowers; contaminate foodstuffs or buildings with their feces; and transmit diseases directly or indirectly to man, poultry, or dairy animals.

1. Avicides registered by the Environmental Protection Agency (EPA) for specific species often require prebaiting for several days and the quick removal of dead birds at regular intervals to be effective. Chemosterilents, birth control agents, and repellents are also available. There are three repellent categories: (1) olfactory (odor), (2) tactile (touch), and (3) gustatory (taste). In the olfactory category, gardeners have used naphthalene (moth balls) granules or flakes to repel all domestic animals. Tactile repellents are made of various gooey combinations of caster oil, petroleum, or solvents and applied as thin strips or beads to roosts, window ledges, and resting areas. Taste repellents are varied and have multiple uses. For example, fungicides applied as seed treatments sometimes inhibit seed-pulling birds.
2. To protect sprouting seedlings and maturing vegetables, floating row covers are easy to use and need no supports. Drape cheesecloth, nylon

netting, or other mesh materials over garden crops or fruit trees susceptible to bird damage during ripening. Put these up 2 to 3 weeks before ripening. Place screen or cloth over strawberries and other small fruits.

3. Commercially designed noisemakers are partially effective but not very popular in populated areas. Stakes and flags, continuous string flagging or netting, spiral twirlers, shiny propellers, and other objects that flash in the sunlight, rustle, or rattle as they spin are useful in small areas until birds become accustomed to them.
4. Poisoning is effective but not selective. Invariably, poisons will kill several song or protected birds, so it is not recommended.

B. Yellow-Bellied Sap Sucker

A member of the woodpecker family, sap suckers drill horizontal rows of squarish holes through the bark of spruce, Scots pine, birch, nut trees, and Siberean elm. They feed on sap and sap wood. Hummingbirds will feed on this sap and, like the sap sucker, take advantage of the insects attracted to the ooze. Girdled trees may die. Because sap suckers are a protected species, it is unlawful to kill them; so wrap the damaged trees in burlap and treat with pruning paint. Painting a mixture of cayenne pepper and petroleum jelly on affected areas may discourage continued damage. Noise makers also may scare birds away.

C. Starlings

Exclude starlings (Fig. 6) by closing all openings to less than 1 inch (2.54 cm). Use boards or metal coverings at 45° angles and metal prongs or sticky repellents on ledges or rafters. Attach netting to prevent roosting on buildings or rafters. PVC strips work well to cover door openings. Frightening devices including alarms, distress calls, lights, and bright objects may work. Repellents to protect ripening fruit and poison baits also are available.

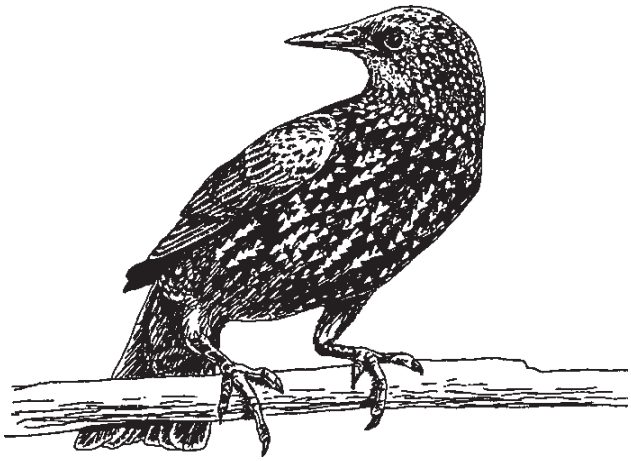
VII. Invertebrates and Arthropods of the Home Yard and Garden

A. Nematodes

Nematodes or eelworms are tiny, unsegmented worms that may be as small as 1/125 inch in length. An impermeable cuticle covers and protects them. They survive during unfavorable periods of cold or heat in protective egg shells. Accurately identifying this pest and learning its specific life cycles (eggs may remain viable in cysts for several years) is the key to proper management.

1. Nematodes cause their greatest damage when soil moisture and temperature are suitable for germination. They frequently will pierce roots and feed on them. They may lay their eggs on roots causing knots to form. Nematodes can transfer diseases between plants. A plant attacked by parasitic nematodes loses nourishment and may appear stunted or die. There are a number of beneficial free living, nonparasitic nematodes associated with root systems of many plants; therefore, finding root knots does not always indicate nematode injury.
2. Control culturally by selecting nematode-free planting stock or resistant plant varieties. You can kill considerable numbers of nematodes by soil solarization, flooding the soil for extended periods, or by permitting the soil to completely dry out. Maintaining high fertility levels or add-

Fig. 6. Starlings can cause damage because of their prolific numbers and flocking habits.



ing organic amendments (peat, manure, and green chop) to garden soils decreases the pest's impact. Some commercial preparations of organisms (bacteria, sporozoa, fungi, viruses, protozoa, predatory nematodes, tardigrades, mites, and springtails) that prey on nematodes are available.

3. Crop rotation is perhaps the most inexpensive, yet effective way to control nematodes. Nematode-suppressive plants such as French marigolds (Tagetes patula), asparagus, garlic, and onions have been reported to abate nematodes if they are planted in blocks and used as part of a rotation.
4. Orchard floor management through the use of cover crops in orchards or vineyards can have a significant impact on nematode problems. Sanitation, preventing the movement of soils or water from an infested area of the garden, and planting or harvest dates based on soil temperature with an understanding of nematode life cycles also may help.
5. Gardeners seldom use nematicides unless they encounter greenhouse or cold frame problems. Most of today's chemical nematicides are soil fumigants, volatile halogenated hydrocarbons. There are no nematicidal agents registered for use in the home garden. If this pest problem occurs, you will need to contact a commercial applicator. To avoid damaging other plants, the products must be applied before planting. Chemical applications must have high vapor pressure to spread through the soil and successfully contact nematodes in the water film surrounding soil particles.

B. Slugs and Snails

These are molluscs, not insects. Both have soft bodies and secrete a silvery mucus that appears as trails across the garden. Snails carry a shell about with them. They spend the winter in the soil as eggs. Young and adult slugs often rest in night crawler tunnels. They appear in early spring and multiply rapidly under moist conditions. There are several kinds, but all are similar in appearance. Their color varies from white to pale yellow to lavender-purple to nearly black with brown spots, specks, and mottlings. They have rasping mouthparts. Slugs are humidity-loving animals that attack all kinds of garden and ornamental plants. They may eat irregular sections or consume entire leaves. There is only one generation per year.



1. Culturally control slugs by eliminating cool, moist, dark hiding places (low-growing weeds, stones, trash, and ground covers) where slugs seek daytime shelter. Keeping the garden dry and plants well spaced can help. Regular hand picking slugs from plants at night, maintaining a border of bare soil, and building copper screens or copper strip barriers that they cannot crawl over may also help. Commercial traps are available. Shallow pans placed at ground level and filled with stale beer are good homemade alternatives. Shingles, boards, and flower pots placed on the ground as hiding places also make good traps; check traps daily and scrape off and destroy the slugs. Commercial preparations of diatomaceous earth can be effective as a protective barrier if kept dry. Among their natural enemies are ladybug larvae, ducks, chickens, snakes, and turtles.
2. You can chemically control slugs by using molluscicides such as metaldehyde baits. Note these baits may attract and be toxic to pets. Improve the bait's effectiveness by placing it under a protective cover such as a 5-inch diameter pie pan. Fresh baits are most effective. Do not allow bait to come in contact with edible parts of plants. Methioacarb (Mesurol) is the most effective of the insecticides registered for use against snails and slugs on ornamentals. Other registered insecticides include Carbaryl and Mexa-carbate.

3. Do not use salt because it contaminates soil and kills plants. A solution of one half household ammonia and one half water in a spray bottle may destroy slugs and snails without harming the soil. Keep the spray solution off leaf surfaces as it can damage plants; however, it will leave nontoxic residues.
4. A mulch of oak leaves or tobacco stem meal will repel slugs and snails. A drenching of wormwood tea will deter them. Hellebore has long been used to keep slugs from grapevines.

C. Earthworms or Nightcrawlers

Earthworms need a moist environment. They are headless, eyeless, toothless, without antennae, and bisexual (they have both male and female reproductive organs). Soils with high worm populations often have high organic matter levels. Saline soils, sandy soils, and soils with a pH of 4.5 or lower usually have few worm problems. Earthworms are normally found in the top 6 to 30 inches of the soil. They come to the surface at night and after heavy rains.

1. Earthworms can grow to 10 inches in length. Most gardeners feel they are beneficial, but for some their burrowing and hard casts make a lawn lumpy and difficult to mow. Earthworms burrow through soil, feeding on organic matter and dead leaves or stems at the soil surface. They decompose thatch, mix organic material through the soil, and aerate the soil with their tunneling.
2. Culturally some lawn maintenance professionals use heavy lawn rollers in the spring before the mowing season, or when problems occur, to level the ground.
3. No chemicals are registered for earthworm control.

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Chapter 13
Plant Disease Diagnosis and Management

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I. Introduction to Plant Diseases

Plant pathology or phytopathology is the science dealing with plant diseases and their control. Plant pathologists study plant diseases caused by fungi, bacteria, viruses, nematodes, and parasitic plants. They also study plant disorders caused by nutrient imbalances, air pollution, and other unfavorable growing conditions.

A. History of Plant Diseases

Plant diseases have had profound effects on mankind through the centuries as evidenced by Biblical references to the blasting and mildew of plants. The Greek philosopher Theophrastus (370-286 B.C.) was the first to describe maladies of trees, cereals, and legumes that we currently classify as leaf scorch, rots, scab, and cereal rust. The Romans were also aware of rust diseases of their grain crops. They celebrated the holiday of Robigalia when sacrifices of reddish-colored dogs and cattle were made in an attempt to appease the rust god Robigo.

With the invention of the microscope in the 17th century, fungi and bacteria associated with plants were investigated. In 1665, Robert Hooke published the first illustration of rust on a rose leaf. Advances in the study of diseases were hampered by the widely held belief in the theory of spontaneous generation. This theory, held by most people in the mid-18th century, considered pathogenic or disease causing microorganisms as products of disease rather than causes of disease.

Epidemics of late blight of potato devastated Ireland in 1845 and 1846. These epidemics dramatized the effect of plant diseases on mankind. Tragically, these epidemics caused famine and death for over a million people. Between 1845 and 1860, death and migration accounted for the loss of nearly one-third of Ireland's population.

In 1861, a German botanist, Anton De Bary, proved that a fungus (*Phytophthora infestans*) was the causal agent of late blight of potato. This was a milestone in the study of plant diseases since it showed that a fungus was indeed the cause of a plant disease rather than an organism simply associated with the disease. Two years later, Louis Pasteur proposed his germ theory of disease that finally disproved the theory of spontaneous generation and changed the way modern science investigated the diseases of all living organisms.

B. Significance of Plant Diseases in the United States

A few examples of plant disease epidemics that have resulted in devastating plant losses in the United States include: chestnut blight, introduced in 1904, virtually eliminated chestnut trees from North America; citrus canker, introduced in 1910, and a closely related bacterium called citrus bacterial spot discovered in 1984, resulted in the destruction of millions of citrus trees; white pine blister rust, introduced in 1912, caused large economic losses in the timber industry; and Dutch elm disease, introduced in 1930, continues to destroy large numbers of elm trees from the East Coast to the Pacific Northwest.

As a direct result of severe disease losses from imported diseased plant material, plant quarantine laws were passed by the United States Congress in 1912. The Agricultural Plant Health Inspection Service (APHIS) has quarantine inspectors stationed at points of entry into the country as well as at certain interstate points to intercept produce likely to carry new plant pathogens.

II. Disease Concepts

A. What Is a Disease?

There are many ways to define what a plant disease is. However, simply put, plant diseases involve profound changes within the host that cause a disruption of normal plant function. A good working definition of a healthy plant is one that can carry out its physiological functions to the best of its genetic ability.

Diseases are among the most important factors that can significantly diminish growth and yield, or reduce the usefulness of a plant or plant product. Healthy or normal plants develop and function to the maximum of their genetic potential. However, when plants are adversely affected by continuous irritation by a disease-causing agent, which interferes with normal development and functioning, plants are considered to be diseased. This broad definition excludes injury or damage such as mechancial injury (e.g., lawn mower or weed-eater injury to trees); deer, rodent, and bird damage; hail damage; and lightning injury.

In addition to reduction in growth, yield, and economic or aesthetic value of a plant or plant product, diseases may lead to the death of the whole plant or destruction of the entire crop under conditions favorable for the disease. Diseases may interfere with absorption and translocation of water and nutrients from the soil to the various parts of the plant, may reduce the photosynthetic efficiency of the plant parts, may interrupt the translocation of photosynthetic products through the plant, or may interfere with the reproduction and storage of food reserves in the plant.

Diseases in plants are caused by either living (biotic, parasitic, or infectious) agents called pathogens, or nonliving (abiotic, nonparasitic, or noninfectious) environmental factors. Plant diseases may also be grouped by the causal agent involved (fungal diseases, bacterial diseases, viral diseases, nematode diseases, etc.), the plant part affected (root diseases, seedling diseases, leaf diseases, stem diseases, flower diseases, fruit diseases, tuber diseases, etc.), or the types of symptoms (damping-off, wilts, leaf spots, cankers, blights, galls, root knots, mosaics, storage rots, etc.).

B. Symptoms of Diseases

Symptoms are the visible reactions of a plant to a disease and may suggest a causal agent. A sampling of disease symptoms might include wilting, necrosis, abnormal coloration, defoliation, fruit drop, abnormal cellular growth, or stunting of the infected plant. However, it is important to remember that different disease agents can cause similar symptoms on the same host. An equally important point to remember is that insect feeding can also cause disease-like symptoms on plants.

C. Signs of Diseases

Signs are the visible parts of the pathogen or its products seen on the host that can be used to identify the pathogen. Examples of common disease signs include: the white coating of mycelium visible on powdery mildew-infected leaves, mushroom growth on a tree limb, droplets of bacterial ooze running down a fruit tree twig, nematode cysts on plant roots, or dark fungal fruiting bodies visible in leaf lesions.

D. Causal Agents of Disease

A pathogen is any organism that can cause a disease. Pathogens cause infectious diseases that can spread from an infected plant to a healthy plant. Pathogens that cause infectious diseases include bacteria, fungi, viruses, nematodes, and parasitic plants. Plant disease can also be caused by noninfectious or nonliving factors. Causes of disease by nonliving factors include unfavorable growing conditions, mineral deficiencies, and air pollution.

Pathogens that cannot be cultured apart from their host are classified as obligate parasites. Pathogens that can be cultured apart from their hosts on artificial media are called nonobligate parasites. In general, obligate parasites only attack very specific host plants, whereas nonobligate parasites typically have a wider range of plants they can infect. Some pathogens are restricted to a single plant species, while others infect a single plant genus. Still others attack a large number of hosts from many plant genera.

There are also several levels of parasitism that pathogens can have with their hosts. When a pathogen is capable of infecting a plant, the plant is considered susceptible to that pathogen. If a pathogen cannot infect a plant, then the plant is considered immune to that pathogen. Plants can vary in their response to pathogens from high resistance (very little disease development), to partial resistance (moderate disease development), or high susceptibility (severe disease development). Pathogens can vary in their degree of virulence on a susceptible plant ranging from highly virulent (causing severe disease symptoms) to weakly virulent (causing less disease).

E. Inoculum and Pathogen Dissemination

Inoculum is any part of the pathogen that can cause infection. Examples of inoculum include fungal spores, bacterial cells, virus particles, or nematode eggs. Inoculum that survives the winter and causes the original or primary infection in the spring is called primary inoculum. Secondary inoculum causes additional infections throughout the growing season.

Inoculum is sometimes present at the site where a plant is grown and can also be introduced from an outside source. Inoculum already present at a plant site includes soil pathogens or pathogens that overwinter on perennial weeds. Introduced inoculum includes infected plant material such as infected seeds, wind-blown fungal spores, and inoculum transmitted by insects.

Inoculum can be disseminated passively by wind, rain, and man. Inoculum can also be disseminated actively by insects and nematodes or fungal zoospores swimming through water in the soil toward plant roots. Only a fraction of any pathogen's inoculum will ever land on a susceptible host. The vast majority of inoculum lands on material that cannot be infected. Most pathogens produce a tremendous surplus of inoculum.

F. Pathogen Survival

Pathogens in temperate climates must have a way of overwintering when their host plants are dormant or absent. In perennial plants, pathogens can survive in infected plant parts such as roots, bulbs, stems, and bud scales. Annual plants, however, die at the end of the growing season and pathogens must survive in insects, seeds, or as resistant spores.

G. Factors Affecting Disease Occurrence

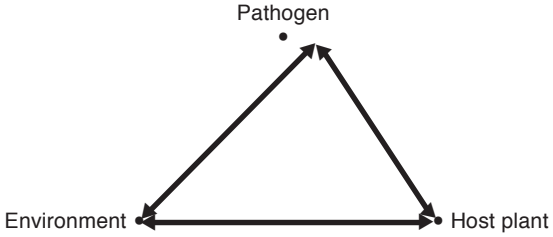
Diseases in plants are an exception rather than a rule. Three factors, called the disease triangle (Fig. 1), must coincide for a plant to become diseased: the host, the pathogen, and the environment. The interaction between these three factors with time determines the occurrence and severity of a disease. For the disease to occur, the following conditions must be met:

1 The host plant must be of a susceptible species or cultivar at the right stage of development (susceptible host).

2. The pathogen must be of a virulent race or strain and must be present in sufficient numbers (inoculum potential). The presence of appropriate vectors or other agents of dispersal is also necessary.

3. The environmental (atmospheric and soil) conditions such as temperature, humidity, rainfall, wind, moisture, light, soil type, texture and pH, density of planting, aeration, and nutritional status (mineral deficiency or excess) must be favorable for disease development.

Fig. 1. Plant disease triangle.



4. Understanding the various aspects of the host, the pathogen, the environment, as well as their interaction is essential to implement an effective disease management strategy.

III. Diseases Caused by Living (Biotic, Parasitic, or Infectious) Agents

A. Fungi

Commonly known as molds, fungi (singular = fungus) are mostly microscopic organisms that have bodies (mycelium) composed of multi-cellular, thread-like, branched filaments (hyphae) and reproductive structures called spores. Since they do not possess chlorophyll, fungi depend on either dead organic matter or living plants for their growth and reproduction. Some fungi produce vitamins and antibiotics that are useful to us.

A few fungi, like some types of mushrooms and morels, are edible. On the other hand, some fungi thrive on living plants, drawing their nutrition from them and sometimes producing toxins that cause disease and death of the plants they infect. These are called plant pathogenic fungi.

A majority of diseases in plants are caused by fungi. Some examples commonly encountered in home gardens and landscape trees are: brown rot of cherries, apple scab, black spot of rose, snapdragon rust, corn smut, powdery mildew of rose, peach leaf curl, sycamore anthracnose, early blight of potato, Verticillium wilt of tomato, damping-off, and root rot of vegetables.

B. Bacteria and Phytoplasmas

Bacteria (singular = bacterium) and phytoplasmas (formerly known as mycoplasmas or mycoplasma-like organisms) are microscopic, single-celled organisms that cause some of the most destructive diseases in plants. Some bacteria, like those that induce nodulation in leguminous plants, are beneficial to plants because they fix nitrogen from the air into the root nodules in a form that the host plant can utilize for its growth.

Phytoplasmas are a type of bacteria that lack distinct cell walls. Under favorable conditions, bacteria reproduce very rapidly and can cause serious damage in a short period of time. Bacterial pathogens are spread by wind-splashed rain, insects, contaminated seed, or implements. Bacterial diseases are relatively difficult to control because there are very few chemicals that are effective against them.

Some commonly encountered bacterial diseases are: crown gall of rose, grape, apple, cherry, and other ornamental plants; fire blight of apple and pear; soft rot of potato; ring rot of potato; and aster yellows phytoplasma on carrots, tomatoes, onions, lettuce, etc.

C. Viruses

Viruses are infectious agents so small they must be observed through an electron microscope. Particles of these viruses may be in the form of rods, spheres, or threads. They are composed mainly of a nucleic acid core surrounded by a protein coat. Viruses can multiply only in a living host cell and can often spread systemically throughout the infected plant.

Viruses can be transmitted from infected to healthy plants mechanically, through grafts, and by contaminated propagating material. Viruses can also be transmitted by certain organisms, referred to as vectors. In addition to insects (primarily aphids, white flies, leafhoppers, and beetles), virus vectors include mites, nematodes, and fungi in the soil.

Viral diseases are not controlled by pesticide chemicals. Examples of viral diseases are: curly top of tomato, bean, cucurbits, etc.; potato leaf roll; bean common mosaic; and rose mosaic.

D. Nematodes

Nematodes are microscopic roundworms that live in soil as well as water, and survive as eggs or cysts. Most of them are saprophytes, but some infect living plants and cause diseases. Most plant parasitic nematodes feed on the underground parts of the plants (roots, tubers, bulbs, etc.) causing lesions or root knots. However, a few nematodes also affect the buds, leaves, flowers, and stems of plants. Nematodes spread

through contaminated planting material (tubers, seedlings, etc.), manure, soil, water, machinery, and implements. Some nematodes are vectors of plant viruses.

Some examples of plant parasitic nematodes are: root knot nematodes of tomato, potato, beans, and many other plants; root lesion nematodes of corn and potatoes, cyst nematode of sugarbeets; stubby root nematode of corn; stem and bulb nematodes of onion; and foliar nematode of chrysanthemum.

E. Parasitic Higher (Flowering) Plants

Several flower- and seed-producing plants live as parasites on other plants (host plants), deriving their nutrition from them and adversely affecting the host plant's growth and yield. Dodder (also know as strangleweed and devil's hair), for example, parasitizes several garden plants such as potatoes and carrots. It produces orange or yellow vine strands that entwine the stems and other plant parts from which it draws its nutrition through tube-like structures it introduces into the host tissue. Dodder produces abundant seeds that ensure its propagation and spread. Another example of a parasitic plant is dwarf mistletoes on pines.

IV. Diseases Caused by Abiotic (Nonliving, Nonparasitic, or Noninfectious) Agents

A variety of environmental and cultural factors can cause diseases in plants. Since these diseases occur in the absence of pathogens, they do not spread from a diseased plant to a healthy plant.

A. High or Low Temperatures

When plants or plant parts are exposed to high temperatures for prolonged periods, symptoms of scorching or scalding may develop. Some examples are: sunburn or scorching of leaves and sunscald of fruits (e.g., apples, tomatoes, peppers, and melons). Similarly, low temperatures, like frost or freeze, can damage the exposed or sensitive organs (buds, flowers, young fruits, etc.) or may kill the entire plant. Examples include: southwest-side damage to trunks of apple trees; frost damage to blossoms and young apple fruits; russet ring (caused by frost) on apple and pear fruits; winter injury to trees; and frost damage to tomatoes, beans, potatoes, etc.

B. High or Low Soil Moisture

Too much moisture due to excessive watering, poor drainage, ponding, or flooding may cause plants to turn yellow and be stunted. Potted indoor plants, for example, may show poor development or root rots. Seedlings are vulnerable to damping-off caused by soilborne pathogens under these conditions.

In some indoor or greenhouse plants (e.g., geraniums, begonias) growing under warm, humid atmospheric conditions and excessive soil moisture, a condition known as edema (small, wart-like rusty, corky bumps) can develop on the underside of the leaves, and on the stems. At the other extreme, low moisture or drought conditions can lead to poor development, wilting, and death of plants.

C. High or Low Light Intensity

High light intensity is usually not a problem but low light conditions, especially for indoor plants, can lead to etiolation (spindly or lanky plant growth with chlorotic yellow foliage).

D. Lack of Aeration or Low Oxygen Supply

Low aeration can deprive plant roots of adequate oxygen and can adversely affect their development or even kill the plant. Inadequate oxygen supply during the storage of potato tubers can lead to the development of a condition called blackheart, the browning and death of internal tuber tissue.

E. Air Pollution

Certain chemcals, such as ozone, sulfur dioxide, and nitrogen dioxide are released into the air from factories, power plants, and automobile exhausts. These chemicals can accumulate in the atmosphere in sufficient concentration to cause damage to plants.

Ozone damage appears in the form of mottling, chlorosis, spots, and bleaching of young leaves. This is common in certain regions of the country where there is a high ozone concentration in smog. For example, ozone damage is frequently found on the leaves of beans, petunias, and grapes. Some of the air pollutants responsible for acid rain

cause damage to vegetation in certain regions. In Idaho, however, plant damage due to air pollution is not common.

F. Nutrient Deficiencies

Plants require several major (nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur) and minor (iron, boron, copper, zinc, etc.) elements for normal growth. Deficiency or lack of any of these essential nutrients results in disease symptoms in the plant. Specific symptoms depend on the plant species and the deficient nutrient. If not corrected, a prolonged acute deficiency of essential nutrients can lead to death of the plant.

Common examples of nutrient deficiencies are: nitrogen deficiency in beans, iron deficiency in peaches, zinc deficiency in apple trees, and calcium deficiency in apple fruit (bitter pit). In the home garden, the common blossom-end rot of tomato fruit is caused, in part, by calcium deficiency.

G. Mineral Toxicity

Presence of excessive available amounts of certain minerals in the soil can lead to mineral toxicity to the plants. The extent of injury depends on the mineral, its concentration, and the species of the plant. Excessive amounts of sodium salts in the soil can lead to high pH and to alkali injury (e.g., alkali injury to apple). Plants growing in acidic soils can be injured by aluminum or manganese toxicity.

H. Unfavorable Soil pH

Although many plants can grow in a rather wide range of soil pH, plants growing in soils with unfavorable pH usually show poor growth and mineral deficiency or toxicity symptoms.

For example, iron deficiency symptoms are very common in plants growing in high pH soils in Idaho. Under conditions of high soil pH, iron in the soil becomes unavailable to the plant, thus inducing interveinal chlorosis and yellowing of leaves. The plant may die if the condition remains uncorrected for a prolonged time.

I. Pesticide Toxicity

Some pesticides, if improperly used, can cause serious damage to plants. For example, if wettable sulfur is sprayed (for powdery-mildew control) on a very hot day (above 90°F), it will result in injury to the plant phytotoxicity). However, the most common type of chemical injury to plants is due to soil residues or spray drift of herbicides.

Examples of pesticide toxicity are: 2,4-D damage to beans and tomatoes, dicamba (Banvel) damage to vegetables and trees, and glyphosate (Roundup) damage to fruit trees. Some herbicides used as soil sterilants may leave the soil unsuitable for any plant growth for several years.

J. Improper Cultural Practices

Any cultural practice done in the wrong way or at the wrong time can result in significant damage to plants. Injury can result from improper amounts of chemical fertilizer or pesticide or improper chemical mixes in the spray tank. Root pruning can result from excessively deep cultivation; distorted and twisted roots can result from pot-bound conditions of a plant. African violet leaves sprinkled with very cold water develop rings and ring-like patterns that resemble symptoms caused by some viruses.

V. Diagnosing Plant Disease Problems

A. Why Is Diagnosis Important?

Whether in an effort to save existing plants or to prevent problems from recurring, it is important to know "What went wrong?" Diagnosis is the process of gathering information about a plant problem and determining the cause. Once the cause has been determined, it is then possible to recommend a solution or remedy.

Diagnosing plant problems can involve considerable detective work. Sometimes there is insufficient information and other times, the primary cause of a problem is hidden by more obvious, but less-important, problems. Success in diagnosing plant problems depends on how much we know about the host plant, about the plant problems in general, and the quality of information obtained from the client.

For example, 10 tomato plants all similarly damaged, are brought to you. All have yel-

low leaves, stunted growth, and very few feeder roots. You learn from questioning the grower that he applied one-half of a 20-pound bag of 10-10-10 fertilizer to a tomato plot that measures 60 square feet. The grower put 10 pounds of fertilizer on 60 square feet, which translates to a rate of 166 pounds per 1,000 square feet. This is almost 10 times the normal rate of 20 pounds per 1,000 square feet of a 10-10-10 fertilizer. The grower's fertilization rate is enough to kill fine feeder roots. The diagnosis is damage to the roots caused by overfertilization.

B. Basic Steps in Reaching a Diagnosis

1. Identify the plant—The better your plant identification skills the faster you will be able to diagnose a problem. Most references on plant pests and diseases are organized by plant, so knowing the plant is the essential first step in using many reference books.
2. What is normal? Your familiarity with the normal appearance and cultural requirements of the plant will enable you to differentiate normal changes from symptoms of a problem.
3. What is the problem? To make a disease diagnosis, you need to know: the pattern of distribution of the diseased plants or plant parts, the plant species or cultivar involved, the site where the plant is growing (field, orchard, garden, greenhouse, inside the house, etc.), and previous crop history of the site.

   For example, uniform damage to many species in an area, to all plants on one side of the field or garden, or to all shoots on one side of the tree indicates that the cause may be an abiotic factor. Also, if the damage is well demarcated in a garden or in a plant, it may suggest that some abiotic factor is involved. On the other hand, if there is evidence of progressive spread of the disease from an initial focus to other plants of the same cultivar or species or to different parts of the plant, it may indicate that an infectious agent is involved.
4. Examine the plant and note symptoms and signs —For a presumptive diagnosis of diseases in plants, look for the symptoms and signs of the disease. The characteristic internal or external alterations of a plant in response to a disease-causing agent are called symptoms (leaf spot, necrosis, blight, canker, wilt, lesion, gall, witches' broom, rot, chlorosis, mosaic, etc.). Sometimes, the pathogen that causes the disease produces its own characteristic growth or structures on the diseased plant that are of diagnostic value. These are referred to as signs of the disease (mold, mildew, sclerotia, mushrooms, conks, etc.).
5. Tentative diagnosis—Based on your knowledge of the plant and information from reference books, formulate a tentative diagnosis. This will help you focus your examination of the plant and assist in collecting relevant information.
6. Double-check the diagnosis—Once you have arrived at a diagnosis, unless it is an obvious diagnosis, double-check it. Ask other master gardeners or extension educators for their opinions. Read through the reference books about your diagnosis to make certain everything matches. Additional laboratory work may be needed to confirm your diagnosis.
7. Types of plant disease diagnosis—Verbal descriptions by a telephone call or evaluation of a sample provide the most common diagnostic opportunities. However, a site visit provides more complete information.

   To make a telephone diagnosis, you must completely rely on information provided by the caller in order to make your diagnosis. There will be common, familiar problems, such as powdery mildew of apples, when a little information easily leads to a correct diagnosis. In other cases, it will be very difficult to make a diagnosis over the telephone and it may be necessary to evaluate a sample.

   Much of your diagnositic work as a master gardener will be done with plant samples. Usually, the sample will provide the clues necessary to solve the problem. But when the sample only confirms the

identification of the plant, you must concentrate on acquiring information to reach a diagnosis. Your job will be to learn about the plant's cultural and environmental conditions, the care the plant has received, and whether the sample is representative of the problem affecting the plant.

A site visit provides the greatest opportunity to gather information, but a successful plant diagnosis also depends on a combination of factors: your knowledge of the plant involved, your understanding of the plant's basic cultural requirements, and your recognition of the potential problems that might affect it. It also depends on your ability to gather information, both through observation of the plant and discussion with the client.

VI. Principles of Plant Disease Control

Plant disease control aims at preventing or reducing the amount of damage or economic loss. Most plant disease-control measures are aimed at preventing or protecting plants from the disease rather than curing the plant after it is diseased. By the time the disease symptoms appear, it is often too late to reverse the damage caused by the disease agent. In some cases, acceptable control measures are not available to halt the disease, short of plant removal. Correct diagnosis of the disease is important in order to implement a control strategy to prevent or reduce the incidence of the disease in the next crop cycle.

The various controls for diseases can be classified as exclusion strategies, inoculum reduction methods, use of disease-resistant cultivars, chemical control, and biological controls. Integrated disease-management strategies may utilize any or all of these methods.

A. Exclusion of the Pathogen

Some destructive plant diseases do not occur in our country, state, or region. To prevent import and introduction of these pathogens national, regional, or state regulations, known as quarantines, are put into force. Some examples are the customs and plant health inspection services at airports and check points on highways. In addition, national and state laws regulate the conditions under which certain crops may be grown and distributed between states and countries. We cannot import several types of plant material from abroad without specific permission and inspection by the appropriate quarantine authority.

An example of a state quarantine is in relation to white rot of onion and garlic. White rot is a very destructive disease of onion and garlic. Once introduced in the soil, the pathogen can survive for over 20 years and there are no satisfactory chemical control measures. At present, our commercial onion growing areas in southern Idaho are free from this disease. Therefore, the State Department of Agriculture in Idaho restricts the importation of onion and garlic bulbs and other related plants for planting in southern Idaho.

Restriction of bean seed from outside of Idaho prevents the introduction of two serious bacterial diseases: halo blight and common blight.

Homeowners can keep some serious plant pathogens out of their yards and gardens by planting only certified, disease-free planting material (seeds, tubers, bulbs, seedlings, nursery stock, etc.). For example, a homeowner can avoid several virus diseases and ring rot of potato by planting certified disease-free tubers.

B. Eradication or Reduction of the Pathogen Population

Serious disease damage to a crop or garden patch can be prevented or reduced by pulling out and destroying the first plant or the first few plants that show the disease symptoms (roguing). This prevents the spread of the pathogen to other healthy plants (e.g., elimination of the first bean plants with mosaic symptoms).

Since some of the root-infecting pathogens remain viable in the soil even after the crop is harvested, avoid planting the same or similar susceptible crop in that part of the garden for the next 2 to 3 years. An appropriate crop rotation in the garden is very essential to reduce the damage caused by root rot and wilt-causing pathogens and nematodes (e.g., Fusarium root rot and wilt, Ver-

ticillium wilt, and nematodes on tomato).

Eliminating the infected leaves and diseased or dead branches, as well as using clean garden tools and similar methods of sanitation, will prevent the spread and build up of disease-causing organisms.

Other cultural practices, such as growing plants on raised beds and using composted tree bark in the planting medium for containerized nursery stock, help reduce the damage caused by certain soilborne pathogens (e.g., damping-off, root rots, and wilts).

Proper irrigation management can prevent some diseases (e.g., collar rot of apple).

Using the sun's heat during the summer months to reduce some of the soilborne pathogens can be successful in certain regions. In this process, called soil solarization, the soil is cultivated to a fine texture and deeply watered.The moist soil is covered with a clear polyethylene sheet. The sheet's edges are buried to create an airtight environment. The moist soil below the polyethylene mulch heats up and is slowly "cooked." Under sunny weather conditions for at least 4 weeks, this process reduces or eliminates several soilborne pathogens.

Marigolds interplanted with nematode-susceptible crops produce substances in the soil that are toxic to plant parasitic nematodes and thereby reduce the nematode damage to the crop plant.

Controlling insects with insecticides can reduce the spread of some of the diseases caused by viruses that are transmitted by insects (e.g., potato leaf roll virus spread by aphids).

C. Use of Disease-Resistant Cultivars

Where available, use of disease-resistant cultivars is the most cost-effective, safe, easy, and environmentally desirable option for the gardener. In fact, for some diseases (such as curly top of tomato), resistant cultivars offer the only practical control option available. Varieties resistant to one or more diseases are available in several vegetables and fruits (e.g., tomato cultivars with resistance to Fusarium wilt, Verticillium wilt, nematodes, and tomato mosaic virus; and apple cultivars resistant to fire blight).

D. Chemical Protection of Plant

The most common method of direct protection of plants against plant pathogens is through the use of chemicals. Chemicals used for control of fungal diseases are called fungicides, those that control bacterial diseases are called bactericides, and those that control nematodes are called nematicides. No chemicals at this time are effective against diseases caused by viruses.

Certain chemicals, used to control soilborne pathogens, are called fumigants. These are highly volatile chemicals that are toxic to all the living organisms (biocides), including insects, weed seeds, fungi, bacteria, and nematodes. An example of a soil fumigant is methyl bromide. Fumigants need extreme care in handling and application, and therefore, can only be used by certified pesticide applicators.

Based on the mode of action, pesticide chemicals can be classified as follows:

Protectants: These chemicals, when applied to the plants, remain on the plant surface and prevent spore germination and infection of the plant by the pathogen (e.g., sulfur, captan).

Systemics: These chemicals are absorbed by plants and are translocated to other plant parts (e.g., Benlate, Ridomil).

Eradicants: These chemicals can eradicate the pathogen from plant tissue after the infection has occurred; that is, after the penetration by and establishment of the pathogen inside the host tissue (e.g., Rally).

Based on the type of chemical (active ingredient), these pesticides can also be classified as copper compounds, sulfur compounds, dithiocarbamates, benzimidazoles, antibiotics, etc. Disease-control chemicals can be applied as seed treatments, foliar sprays, dusts, fumigants, wound paints, dips, or through irrigation water (chemigation).

The effectiveness of chemical control measures is dependent upon our understanding of the disease cycle, host susceptibility, tim-

ing, mode of application, coverage, and choice of the appropriate product. Timing of the application and thorough coverage of the plant surface are very important for effective disease control. For best results, most chemicals are applied before the pathogen infects the host. Also, most chemical sprays have to be applied several times at regular intervals for best disease control.

Always follow the label directions and precautions. Development of pathogen strains resistant to chemicals or antibiotics (e.g., streptomycin-resistant strains of apple fire blight pathogen) can lead to these products becoming ineffective in disease control.

E. Biological Control

The strategy for biological control of plant diseases involves the use of antagonistic microorganisms before or after infection takes place. There has been successful control of crown gall with strain K84 of *Agrobacterium radiobacter,* which produces an antibiotic specific against crown gall bacterium. Commercial biological control agents are available as seed treatments and soil amendments to protect plants against soilborne pathogens.

Currently, the bacteria *Bacillus subtilis* and *Pseudomonas* spp. and the fungi *Gliocladium virens* and *Trichoderma* spp. are the organisms with the most applications in biological control strategies. There is tremendous research interest in developing new biological tools for plant disease control, but research-based options are limited at this time. Genetic engineering of biocontrol microorganisms has sparked wider environmental concerns, which will limit the speed of this new technology's use in plant disease control.

F. Integrated Disease Management

An effective, economical, and sustainable disease management strategy should incorporate all the available approaches of a disease management program. It should include the relevant preventive and control measures appropriate for the crop, such as selection of planting site, selection of the most adapted and disease-resistant variety, crop rotation, pathogen-free planting material, seed treatment, appropriate planting date, planting depth and density, irrigation and fertilizer use, weed control, sanitation, timely pesticide applications, proper harvesting, and handling and storage of the produce. The integrated disease management measures selected should be effective (should control the disease), economical (should result in an economic return), and sustainable (should be environmentally sound).

VII. Plant Disease Terms

Anthracnose—Black or brown dead areas on leaves, stems, or fruits (anthracnose of sycamore, maple).

Blackleg—Darkening at the base of a stem (blackleg of potato).

Blight—Rapid death of leaves and other plant parts (fire blight of apple, early blight of tomato).

Brown rot—Soft rot of fruit covered by gray to brown mold (brown rot of cherries, peaches, nectarines).

Canker—Sunken, discolored, dead areas on twigs and branches, usually starting from an injury or wound (Cytospora canker of trees, common canker of rose, fire blight cankers).

Chlorosis—Yellowing or whitening of normally green tissue (iron chlorosis of trees).

Crown gall—Excessive, undifferentiated growth that may girdle roots, stems, or branches (crown gall of grapes, rose, apple, cherry).

Curly top/leaf curl/leaf roll—Rolling and curling of leaves and growing point (curly top of sugarbeet, tomato, bean, etc.; peach leaf curl; potato leaf roll).

Damping-off—Stem rot near the soil surface leading to either failed seed emergence or falling over after emergence.

Epidemic—A widespread and severe outbreak of a disease.

Etiolation—Long internodes and pale green color of plants growing under insufficient light or in complete darkness.

Fumigation—The application of a toxic gas or volatile substance to disinfect soil or a container such as a grain bin.

Fungicide—A compound toxic to fungi.

Host plant—A plant that is invaded by a parasite.

Host range—The various plants that may be attacked by a parasite.

Inoculum—The pathogen or its parts that can cause infection.

Integrated control—An approach that attempts to use all available methods for control of a pest or disease.

Isolation—The separation of a pathogen from its host by culturing on a nutrient medium or on an indicator plant.

Lesion—A localized area of discolored or dead tissue (early blight lesions on potato leaf).

Life cycle—The successive stages of growth and development of an organism.

Microscopic—Organisms so small that they can be seen only with the aid of a microscope.

Mosaic—Intermittent yellowish and green mottling of leaves (bean common mosaic, rose mosaic).

Necrosis—Death of tissue (necrotic area in black spot of rose).

Organism—A living being.

Parasite—An organism that lives in or on another organism (host) and derives its food from the latter.

Pathogen—A disease-causing agent.

Plant disease—Any lasting change in a plant's normal structure or function that deviates from its healthy state.

Plant pathology—The study of diseases in plants: what causes them, what factors influence their development and spread, and how to prevent or control them.

Powdery mildew—Fine, white to gray, powdery coating on leaves, stems, and flowers (powdery mildew of rose, grapes, lilac, and apple).

Resistance—The ability of a host plant to prevent or reduce disease development by retarding multiplication of the pathogen within the host.

Root and stem rots—Soft and disintegrated roots and lower portions of the stem, sometimes results in death of plant (root rot of pea, damping-off of seedlings, collar rot of apple).

Root knots—Swelling and deformation of roots (tomato root knot).

Rust—Raised pustules on leaves, stems, and fruits; contain yellow-orange or rust-colored spore masses (snapdragon rust, geranium rust).

Sanitation—The removal and disposal of infected plant parts; decontamination of tools, equipment, hands, etc.

Saprophyte—An organism that can subsist on nonliving matter.

Scab—Slightly raised, rough areas on fruits, tubers, leaves, or stems (common scab of potato, apple scab).

Shot-hole—Roughly circular holes in leaves resulting from the dropping out of the central dead areas of spots (Coryneum leaf spot of peach).

Sign—The part of a pathogen seen on a host plant (moldy growth, spores, etc.).

Smut—Black masses of spores in galls that may form on stems, ears, etc. (common smut of corn).

Spore—The reproductive unit of a fungus, similar to the seed of a plant.

Susceptibility—The condition of a plant in which it is prone to the damaging effects of a pathogen or other factor.

Symptom—The altered external or internal appearance of a diseased plant (spot, gall, soft rot, etc.).

Systemic—Spreading internally throughout the plant.

Vascular pathogen—A disease-causing organism that invades mainly the conductive tissues (xylem or phloem) of the plant.

Vector—A living organism that is able to transmit or spread a pathogen.

Virulent—Capable of causing severe disease.

Wilt—Drooping and drying plant parts due to interference with the plant's ability to take up water and nutrients (Verticillium wilts, Fusarium wilts).

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Booklets and Pamphlets

University of Idaho Extension

Pesticide Safety

PNW 512	Farm Safety Series
PNW 512S	Farm Safety Series (Spanish)
PNW 278	First Aid for Pesticide Poisoning
CIS 1030	Idaho Homeowner's Commonsense Guide to Pesticides: Storage and Disposing of Home and Garden Pesticides
CIS 781	Laundering Pesticide-Contaminated Clothing and Safety Equipment
CIS 1019	Pesticides for the Home Garden and How to Use Them

Small Fruit

CIS 341	Crumbly Fruit in Raspberries
CIS 789	Diseases of Raspberries in Idaho
CIS 847	Virus and Nematode Diseases of Raspberries

Tree Fruit

CIS 866	Homeowner's Guide to Fruit Tree Fertilization
PNW 121	Nutrient Disorders in Tree Fruits (online only)
CIS 752	Phytophthora Collar-Rot of Orchard Trees

Ornamentals

CIS 869	Controlling Sunscald on Trees and Vines
CIS 1068	Fertilizing Landscape Trees

Gardening

CIS 292	Blossom-End Rot of Tomatoes
CIS 993	Management of Vegetable Diseases in Home Gardens
BUL 775	Planning an Idaho Vegetable Garden

Lawns

BUL 676	Fairy Rings in Turf
CIS 1062	Starting a Home Lawn
CIS 1063	Thatch Prevention and Control in Home Lawns

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Chapter 14
Weeds

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I. Introduction

"A weed is a plant that interferes with the management objectives for a given area of land at a given point in time."

J. M. Torell

A weed is any plant that is growing where it is not wanted and is more competitive than the surrounding desirable plants. Time, energy, and money for weed control can be kept to a minimum by planning carefully and choosing wisely in practices and materials. Effective weed management involves learning about the weed, understanding the particular site and situation, and employing a diversity of practices to provide desirable results.

Weeds are not only unsightly but also compete with desirable plants for nutrients, water, sunlight, and space. In addition to competing with landscape and vegetable plants, some weeds secrete toxins into the soil which, much like herbicides, damage or inhibit growth of desirable plants. Weeds can ruin lawns, gardens, and flower beds. In some situations, weeds can be such a problem that the only practical weed control is to destroy the entire planting.

Weeds can also provide a "bridge" for insects and diseases from one growing season to another. When weeds are present, additional applications of insecticides and fungicides may be required.

Weeds have contributed to several other problems in the home landscape environment. Field bindweed, for example, can grow through asphalt causing premature failure of driveways and streets. Weeds contribute to health problems such as hay fever, respiratory problems, and skin irritations. Some weeds puncture bike tires and injure bare feet. Pets also are affected by weeds. Weed seeds may enter their nostrils and ears causing irritation and infections; weed seeds may become enmeshed in their fur causing discomfort. Often times a veterinarian is needed to remove the seed.

Most homeowners are concerned with weeds that exist near their homes because weeds are a general nuisance, mar the natural beauty of a home site, and decrease the value or marketability of residential properties. Weeds contribute to fire and safety hazards and reduce property values.

Landscapes and yards overgrown with weeds serve as a reservoir of weed seed that can spread to neighboring yards. As a result, some municipalities have ordinances requiring owners to cut down overgrown, weedy lots. A few imported weeds are so invasive and expensive to control that they have been declared noxious and therefore illegal to grow or go to seed.

Although seeds are generally thought of as uninvited guests, weeds do have some limited beneficial characteristics. Weeds can be a source of feed for domestic animals and wildlife, can help prevent erosion, and can add organic matter to the soil.

II. Weed Biology and Classification

The classification of weeds is achieved by grouping together those weeds whose similarities are greater than their differences. For preciseness, weeds are grouped botanically by family, genus, species, and variety. For convenience, weeds are commonly classified in categories such as terrestrial and aquatic, or woody and herbaceous.

Weeds also are classified as trees, shrubs, grasses, sedges, and ferns. Weeds are also commonly grouped according to similar life cycles, that is the cycle of life from viable seed to mature plant and the cycle of viable seed formation to death of plants. On this basis, weeds are grouped as annuals, biennials, and perennials.

A. Annual Weeds

These complete a life cycle in one year. Annuals germinate from seed, emerge, grow, flower, set seed, mature and die in one growing season. Annual weeds depend upon the production of large numbers of viable seeds for long term survival. Many successful weed species produce thousands of seeds per plant (Table 1). In addition, weed seed has varying levels of dormancy that contribute to its persistence (Table 2). This characteristic gives weeds the ability to germinate over a period of many years.

1. Annuals that complete a life cycle during the period from spring to fall are referred to as *summer annuals*. The majority of weeds that are found in the garden or in new lawns and landscapes are summer annuals. Examples of summer annual weeds commonly found in yards include different pigweeds, common lambsquarters, hairy nightshade, common purslane, prostrate spurge, prostrate knotweed, green and yellow foxtail, barnyardgrass, and crabgrass.
2. Annuals that germinate and emerge in the fall, lie dormant during the winter, resume growing in the spring until maturity, and die in the late spring or early summer are referred to as *winter annuals*. Some of the most troublesome winter annual weeds are annual bluegrass, downy brome, and a number of mustards such as shepherd's purse and flixweed.

B. Biennial Weeds

Biennials require two growing seasons to complete their life cycle. Biennials germinate, emerge, and usually form a rosette (radial cluster of leaves lying close to the ground) the first year. During the second year, the plant bolts (produces a flower stalk), flowers, sets seed, matures, and dies. Biennial weeds are not as prevalent as annual weeds in gardens; but they may appear along property borders, in ground covers, and within perennial planting. Biennials that are commonly found in a home garden-landscape site include: sweet clover, common burdock, common mullein, bull thistle, and Queen Anne's lace.

C. Perennial Weeds

These live 3 years or more and reproduce sexually (from seed) and asexually (from vegetative growth). They may or may not flower the first year. Perennials that reproduce from seed are identical to annuals and biennials in the seedling stage and thus are most susceptible to control when they are young. Within a few weeks or months, however, perennials develop vegetative reproductive organs, giving them the ability to propagate and spread asexually. It is this characteristic that makes perennials so difficult to control. Perennials are classified into three different categories based upon how they reproduce.

1. Simple perennials have either a large tap root such as a dandelion or a fibrous root system such as bunchgrass. Simple perennials propagate mostly by seed, but if the roots are broken into pieces, each piece is capable of reproducing new plants.

Table 1. Seed production for common weeds.

Common name	Number of seeds produced per plant
Barnyardgrass	7,000
Green foxtail	34,000
Redroot pigweed	117,000

Table 2. Germination percentages per year of weed seeds buried 8 inches deep.

Common name	Life cycle	1	2	3	4	16	21
		— Percentage of germination after (years) —					
Canada thistle	perennial	21	35	15	6	3	1
Green foxtail	annual	1	3	6	4	0	0
Quackgrass	perennial	21	0	0	0	0	0
Redroot pigweed	annual	9	0	1	11	0	0
Velvetleaf	annual	0	0	45	70	75	57

Gross, W. L., "Viability of Buried Weed Seeds," Journal of Agricultural Research, Vol. 29, No. 7, pp. 349-362.

2. Creeping perennials reproduce by rhizomes (stems) or creeping roots as well as by seed. Quackgrass and field bindweed are good examples.
3. Bulbous perennials reproduce by bulb or nutlike structures and by seeds as well. Purple nutsedge and bulbous bluegrass are examples of a bulbous perennials.

III. Identification

Identification of a weed should be the first step taken in a successful control program. Successful identification of weed species requires that a sample, with as much of the plant as possible, be intact. This includes flowers, stems, leaves, and roots. Careful examination of various plant structures should be used in the identification process to distinguish between "look-a-likes." A knowledge of where and how the weed was growing also will help in identifying which control measures can be used.

A. Flower

This is the structure most commonly used in classifying and identifying plants. However, weed control measures often must be implemented before flowering. When flowers are present, note the arrangement on the stem, their size, shape, color, the presence or absence of various flower parts, and number of petals. These are all important factors in determining the particular family in which a plant is classified. If the plant has set seed, note characteristics such as size, shape, type of fruit, capsules, pods, burs, hardness, and structure.

B. Leaves and Stem

Weeds also can be identified through careful examination of leaves and stem. Stem woodiness, cross section, and the presence or absence of leaves on the stem should be observed. Stem woodiness is classified as herbaceous (a stem that is not woody), semi-woody, and woody (a perennial stem that is entirely woody such as found in a tree). Cross section of the stem refers to the shape of the stem and is often closely tied to leaf arrangement and leaf shape. Stems may be oval, round, triangular, ridged, square, winged, or grooved. Flowering stem leaves may be absent (dandelion) to uniformly leafy.

C. Weed Structure

Leaf arrangement, type, presence or absence of stipules, petioles, and tendrils, venation, length, shape, surface, and succulence are all important clues for identifying weeds.

D. Roots

All the below ground plant parts can also provide information on the plant. Pull or dig up some of the root system and below-ground plant parts. Determine whether it has a fibrous or tap root system and look for bulbs, corms, tubers, or rhizomes.

Identification of the weed before implementing control practices is important but requires more extensive knowledge than what has been covered in this section. *Weeds of the West*, *Weeds of Nebraska and the Great Plain*s, and *Weeds 2.0 for Identification of Weeds of the Western United States* are several excellent identification references available to help identify weeds. County Extension educators and the UI Department of Plant, Soil and Entomological Sciences also are available to assist in identification of problem weeds and to provide suggestions for their control.

IV. Weed Control Methods

Once the weed is identified and biology of the plant is understood, control measures can be considered. "Silver bullets" and "one-shot control programs" that will control weeds without harming nontarget plants are very rare or nonexistent. An integrated approach to weed control is the most efficient and environmentally safe approach. An integrated approach also uses a combination of cultural, mechanical, physical, and chemical techniques to bring weed populations to an acceptable level. Six methods available to the homeowner include prevention, biological, cultural, mulches, mechanical, and chemical.

A. Prevention

Is the most effective, least costly weed control strategy. Avoid the introduction of weed problems through careful examination of materials that will be used in developing the home landscape or garden.

1. Carefully examine the label on packaged seed and bulk seed. Avoid buying seed

containing weed seed. If noxious weed seed is present, return the seed to the supplier and ask for your money back. It is against the law to sell and propagate noxious weeds. Some seed catalog companies sell "wildflower" mixes that may contain noxious weed seed. The scientific names found in the catalog description and on the seed packet should be compared to the list of noxious weeds listed at the end of this chapter. Report the problem to your county weed supervisor who will contact the Idaho Department of Agriculture to lodge a complaint against the company.

2. Inspect nursery plants and transplants before purchase to avoid introducing roots, rhizomes, or stolons of perennial weeds. Buy your plants from a reliable nursery that sells only weed-free plants.
3. Avoid introducing weed seeds, roots, rhizomes, stolons, and bulbs into the garden and flower beds by using weed-free straw, manure, mulch, compost, and soil. Unless these amendments have been sterilized, they probably contain weed seed. Know the source of these amendments before transporting them to your yard. Selecting sources with relatively low weed populations and avoiding sources with undesirable weed species will pay off in the long run.
4. Tillage equipment can easily spread unwanted weeds to relatively weed-free areas. Clean garden tractors, tillers, hand tools, and other equipment to remove soil, weed seeds, and plant parts.

   Irrigation water that flows through canals and streams can transport weed seed to your yard. Screen irrigation water from surface sources.

   "One year's seed, seven years of weeds." Control vegetative and seed sources around the yard and garden. Destroy weeds before they become established, set seed, and mature.

B. Biological Control

This type of control uses other organisms to control weeds. This is not a very practical solution to many weed problems found in urban home horticultural settings, but may find some use on small acreages. Geese can be used to remove actively growing weeds in dormant strawberries, asparagus, peppermint, cane berries, and trees. Hogs will seek out fleshy-rooted weeds in fallow. Sheep and goats can control many weed and brush species in pastures. Insects and diseases also can be used to suppress or kill specific weeds; however, this type of control generally lags behind weed populations. Many gardening enthusiasts have been disappointed in the use of insects and diseases to control weeds.

C. Cultural Control

These practices have been found to be effective and cost efficient in a home horticultural setting. Integrating cultural control components with other control measures minimizes the impact of weeds on desirable plants, yet provides acceptable control.

1. Select competitive plants. Use plant competition to minimize weed establishment, growth, and reproduction. A vigorously growing ground cover that is more competitive than the weeds will lessen the weed problem. Generally, weeds are more competitive than the garden crop species during early development. Weed competition during the first 3 to 4 weeks after the garden emerges will have the greatest affect on the garden yield. Vigorously growing garden crops develop canopies that shade weeds, suppress weed germination, and hinder growth. Garden crops that are slow growing and less competitive should be transplanted. Table 3 shows when selected garden crops are most sensitive to weed competition.
2. Anything that would encourage vigorous growth of desirable garden plants to compete with weeds should be implemented. Provide moisture to desirable plant roots, using a method that will reduce or eliminate the moisture to weeds. Rotate crops to break the natural cycle of weeds, insects, and disease. A rotation may include fallowing or omitting crop production for one or more years. Growing different

Table 3. Weed competition period for garden crops.

Crop	Critical period for weed competition (number of weeks after emergence or transplanting)
Beets	2 to 4
Cabbage	3 to 4
Carrots	4 1/2
Corn	3
Cucurbit family (melons)	5
Onions	12
Peas	3 to 4
Potatoes	3 to 4
Row crops not covered	4
Snap beans	4
Spinach and lettuce	3 to 4
Tomatoes	5

Source: Nelson, J. E., G. McKinney, and J. F. Connor. *Home Garden Weed Management*. EB 58. Dec. 1989. Montana State University, Bozeman.

types of plants in the area each year may also be effective. Plant winter cover or competitive plants rather than leaving soil bare.

3. Alter planting dates. Delay planting until after the first flush of weeds has emerged, then use cultivation to remove small weeds. Plant for optimum growth of desired plants while avoiding growing conditions conducive to weed germination and growth. Seeding lawns in late summer and early fall is a good example of this method.

   Place and time fertilizer applications to maximize plant growth by banding fertilizer applications. Banding or sidedressing fertilizers near desirable plants promotes optimum crop growth while placing nutrients in a less-available position to weeds growing between the rows.

D. Mulches

These are an extremely effective weed-control tool in the garden and around the home landscape. Mulches are soil coverings such as plastic or straw that prevent sunlight from reaching the soil. A mulch conserves moisture and modifies the microclimate and soil temperature around the plant Mulches are categorized as natural or artificial: natural mulches are effective in eliminating annual weeds and reducing the competitiveness of perennial weeds; artificial mulches are effective in controlling both annual and perennial weeds.

1. Natural mulches are applied 2 to 4 inches deep after weeds are removed through cultivation or with an herbicide. They are composed of materials such as bark, grass clippings, leaves, compost, manure, sawdust, wood chips, straw, hay, crushed corn cob, and pine needles. Most natural mulches are considered waste products and are often disposed of in landfills. Many of these mulching materials are free of charge. A visit to your local tree-care expert or gardening store may provide a source.

   As with other materials used in the home landscape, the homeowner should examine and avoid mulch material with weed seeds and live vegetative plant parts capable of establishing new weed infestations. The life expectancy of natural mulch will vary from 1 to 3 years depending on the material used, depth of material, and management associated with the landscape or garden.

   Live mulches such as grasses and legumes sometimes are used between perennial plant rows. These live mulches are grown to a predetermined stage, killed, and allowed to remain in place to decompose over time. In the garden, natural mulches such as straw can be used in planting of asparagus, cabbage, carrots, cauliflower, lettuce, peas, potatoes, turnips, and other cool season crops to reduce weed competition while maintaining cool soil temperatures.
2. Artificial mulches include plastic, polyester landscape cloth, and sometimes newspaper and tar paper. When artificial mulches are used in a landscape application, natural mulches are applied 1-inch deep on top. The natural mulch hides the artificial mulch and protects it from solar degradation. Polyester landscape cloth should be used in landscape applications rather than plastic or tar paper. Polyester

landscape cloth allows air exchange and moisture percolation through the mulch to the root zone. Natural mulches will stay put on polyester landscape cloth but will have a tendency to slide off plastic.

In vegetable garden applications, black plastic is the preferred artificial mulch. It increases the rate at which soils warm during the growing season and it modifies the microclimate for improved growth rates of warm season vegetables such as tomato, muskmelon, watermelon, cucumber, and squash. Black plastic is relatively inexpensive and easy to handle. When black plastic is used, irrigation applications need to be modified from surface or sprinkler applied to drip applications below the plastic. Other colored plastics may enter the commercial market place in the future. Colored plastic mulches such as red has increased tomato yields by 10 to 15 percent over black plastic mulch.

Newsprint also can be used in the garden and can be very effective in reducing weed problems. Newspapers can be turned into the soil at the end of the season unlike black plastic which must be taken up before cultivation. Tar paper can be used to mulch around trees and shrubs, but it is more difficult to apply and is rarely used.

3. A process that has become more popular in recent years is solarization. Solarization uses the sun's energy to raise soil temperatures high enough to kill weeds including seeds, roots, and rhizomes as well as many soil organisms. Solarization is accomplished by laying and anchoring the edges of a sheet of clear plastic over the entire fallowed area to be treated. The soil should be moist to conduct and hold heat, to stimulate weed seed germination, and to prevent dormancy of below-ground vegetative plant parts. The soil should be firm to conduct heat as deeply as possible.

   Maximum weed kill depends upon the amount of bright, sunny weather and weed species. The longest day of the year and most direct solar radiation occurs at vernal equinox, June 21. Plastic should be in position by June 1 and left in place for about 2 months. If precipitation is more than 20 inches per year, solarization may need to be extended into midsummer and may be less satisfactory in such areas.

   Late winter and early spring solarization may reduce weed populations before planting, but it is not as effective as late spring and summer solarization. However, the entire growing season is not lost with this type of solarization. The process for accomplishing this type of solarization is as follows:

   a. Till the garden soil and prepare the seedbed in autumn.
   b. Place clear plastic over the garden in midwinter or soon after snow melt. Solar heat will warm the soil under the plastic whenever the days are warm and sunny, causing seeds to germinate. Sprouted weeds will die as daytime temperatures under the plastic rise to temperatures of 100°F to 130°F which should be high enough to kill most species. Weeds may also die from freezing.
   c. Leave plastic in place and continue solarization until planting time. Because tilling the soil after removing the plastic brings more weed seeds near the soil surface, plant without further tillage.

E. Mechanical Control

   Includes hoeing, pulling, rototilling, mowing, cultivating, and burning. Mechanical methods are best adapted to eliminating annual weeds depending on the species, the particular location, and the type of implement used. Seedling biennial and perennial weeds also can be controlled mechanically. Once the perennial weed is able to vegetatively reproduce, mechanical control is not very effective. Mechanical methods such as hoeing, mowing, and cultivating cut the plant off at or just below the surface leaving the root or rhizome behind to send up new growth. Deeper tillage such as rototilling or

deep plowing may bring some of the roots or rhizomes to the surface, but even if a small root segment or rhizome remains in moist soil, the weed can establish itself again.

In some instances mechanical control can spread weeds to infest new areas. Effective mechanical control of perennial weeds will require cultivation every 14 to 21 days. This repeated cultivation over 2 to 3 years stimulates root development while depleting stored food (carbohydrates) and eventually the plant dies.

1. Hoeing cuts the plant at or just below the soil surface. Hoes should be kept sharp to reduce the effort of controlling weeds. Often times gardeners will use the hoe to dig or aerate the soil. This is an improper use of this tool. Use a shovel or rototiller to aerate soil. Deep cultivation has a tendency to bring weed seed to the soil's surface providing an excellent environment for weed seed germination. Deep hoeing or tillage in the garden also can damage desirable plants. A proper hoeing technique disturbs the soil very little while removing the weed. Many different hoe styles are available.
2. A hand cultivator or tractor-mounted cultivator generally consists of v-shaped teeth which is used to till soil 1 to 2 inches deep. The action of this tool is similar to the hoe, that is it cuts the weed off at or just below the soil surface and drags the small weed root to the soil surface to dry. Other implements such as disk harrows, sweeps, rolling cultivators, and finger weeders are in this same category.
3. Mowing is an effective way of reducing the amount of seed that weeds will produce and eliminating annuals. The practice must be timed to remove the top before seed is produced. Mowing after viable seed has set can be a good way of spreading weeds to new areas. The vigor and stand density of established perennial weeds can be reduced through repeated mowing, although it requires a long period of time.
4. Hand weeding is effective but is a labor-intensive method of removing weeds growing close to desirable plants. Care must be taken that the pulling of the weed does not damage the roots of desirable plants.
5. Burning or flaming weeds is generally done with a propane torch. Timing of the operation must be such that control is performed before viable seed set. The most effective control of annual weeds is when they are small (about 3 to 5 inches tall). The effect of burning perennial weeds is similar to that of mowing.

   Consider carefully where and when this method is used, since it is more difficult to control in tall dry weeds than previous methods outlined. There have been cases in which out-of-control burning operations have burned a straw pile, barn, or home. Check with local ordinances and regulations before burning perennial weeds.

F. Chemical Control

This method can save labor while providing acceptable control. When used correctly, chemical control can be an inexpensive weed control tool. However, it does have some drawbacks. Herbicides can injure or kill desirable plants and are expensive if used improperly.

Extension educators are often asked to investigate injured or dying trees, shrubs, and other desirable landscape or garden plants that "the neighbor sprayed" only to find out that the gardener used herbicide inconsistent with the label's instructions.

Thoroughly read the label of any herbicide. Be sure the beneficial plant to be protected is listed on the label. Timing of the herbicide applications must follow the label instructions. Even an application of 2,4-D for control of weeds in lawns can injure grass if applied during the heat of the summer. **Always read and follow label directions!**

1. Herbicides usually are not used in vegetable gardens for several reasons:
   - No single herbicide can be used safely on all vegetables grown in a garden;

- Some herbicides can persist in the soil and injure sensitive vegetable crops the following year;
- Spray drift can injure sensitive plants growing in the garden.

2. Herbicides are grouped into families based on chemical properties and how the chemical works to kill the plant. Herbicides also are grouped by when they are applied to control weeds.

   Preemergence herbicides are applied before the emergence of the weed or crop. Herbicides in this group kill weeds as they germinate. These herbicides are further classified as preplant and postplant preemergence herbicides. Preplant herbicides are applied to the soil before planting the desired crop and before the weeds germinate. Postplant herbicides are applied after the desired crop has been planted but before the weeds or crop have germinated.

   Generally, preemergence herbicides are applied to the surface of the soil and either watered in (precipitation or irrigation) or mechanically incorporated into the soil. Failure of these herbicides to work may be the result of poor incorporation because weeds are already germinated.

   Postemergence herbicides are designed to kill emerged weeds. These herbicides may be translocated (e.g., 2,4-D) or may be contact herbicides (e.g., paraquat). Translocated herbicides are applied to foliage or soil. Plants absorb the herbicide through leaves, stems, or roots; and move it through the plant to the site of herbicidal action (where the herbicide works). Translocated herbicides work well on perennial plants because the herbicide is moved to roots and other belowground vegetative reproductive parts.

   Contact herbicides are applied to the foliage of the plant. These herbicides kill only where they directly contact the plant and do not move within the plant. Contact herbicides are a poor choice for the control of perennial weeds.

3. Herbicides are further classified as selective and nonselective. If the herbicide kills the weed but does not injure the beneficial plant, then the herbicide is termed selective. If the herbicide injures or kills the weed and beneficial plant, then the herbicide is known as nonselective.

   Herbicides should only be used according to label directions. Registered uses and rates of application are listed on the product label. Improper use or application rate can cause injury or death to nontarget plants even though the product is selective. Selectivity of an herbicide may depend on any one or a combination of the following factors:

   a. Some plants may be able to detoxify the herbicide by metabolizing it into a harmless substance while other plants are killed.
   b. Foliar-applied herbicides may not be absorbed by leaves or stems because various structures (such as pubescence, and thick way cuticles) block the absorption of the herbicide.
   c. Selectivity of a herbicide may also be due to its placement in the soil. Herbicides such as Casoron, when applied correctly by shallow incorporation, will kill germinating weeds and shallow-rooted weeds. Deep-rooted desirable perennial plants will not absorb the herbicide because the herbicide is placed above the root zone.

4. Soil sterilants are applied to the soil to prevent the growth of weeds and other plants. Some sterilants may be applied to foliage with desired results, but they will leave a long-lasting residue in the soil. The length of time that a sterilant will be effective depends on the rate applied and the persistence of the herbicide.

   Extreme care should be taken when using soil sterilants. Some of these products have a tendency to move with water and can easily be leached from the point of application to root zones of beneficial plants (trees, shrubs, and grass) thus injuring nontarget plants. Soil sterilants are not suggested for use in the yard or gar-

den because they are long lasting and difficult to remove if the homeowner decides to change the use of the treated area.

Fumigants are nonselective and can kill seed and plant parts below the soil surface. Fumigants are not readily available and are only used in greenhouse or commercial operations.

5. Herbicides must undergo a series of tests before the labeling of the product for use by the gardener. These tests evaluate the fate of the herbicide in the environment and potential hazards to the user and nontarget organisms. Determining the fate of the herbicides in the environment include how they degrade, how herbicides move with water (leach), how they bind with soil, how quickly they volatilize and drift, and how toxic they are to fish or other nontarget organisms. The label contains most of this information as well as directions for use. Impact to the environment can be minimized by following **all** of the label instructions and environmental warning statements.

   Additional information specific to the behavior of herbicides in plants and soils, use precautions, toxicological properties, and herbicidal use can be obtained from your Extension educator.

V. Herbicide Application Equipment

Several types of application equipment are suitable for weed control. Application equipment ranges in price from inexpensive canister plastic sprayers to elaborate and expensive power sprayers pulled by garden tractors. The most important consideration is to find suitable equipment for the particular job or situation. Choose dependable equipment that will have a long service life and will do the type of job you need. Types of application equipment include:

A. Hand Spray Bottles

Several home and garden herbicides are now packaged in a ready-to-use, disposable applicator spray bottles, much like common glass and window cleaners. They are meant to be used for spot treating small areas or individual weeds.

B. Hose-End Sprayers

These sprayers attach to the end of a garden hose and may be acceptable for soil drenches and preemergence herbicides with a wide margin of safety. Because they are difficult to calibrate and too variable for proper application, hose-end sprayers are not recommended for most herbicides where precision of application is desired.

C. Compressed Air Canister Sprayers

The most common sprayers used by homeowners are 1- to 3-gallon compressed air sprayers. There are metal and plastic models. Both are equally effective, but the plastic model is less expensive. A compressed air sprayer is ideal for spot spraying postemergence herbicides and will provide a reasonably precise application of preemergence herbicides. Problems encountered through the use of this sprayer include nozzle plugging and spray tank corrosion (this is not a problem with plastic or stainless steel sprayers).

Compressed air sprayers do present a safety problem if the pressure in the tank is not equalized with the outside pressure before opening the tank to refill or clean. However, some manufacturers now include a pressure relief valve that eliminates this hazard.

D. Backpack Sprayers

Several models of backpack sprayers are available. These are usually more expensive; but they are versatile, have up to a 5-gallon capacity, and can be maintained at more uniform pressure than canister sprayers. These sprayers are constructed of plastic or stainless steel, but the inexpensive plastic models are preferred. One of the few disadvantages associated with a backpack sprayer is the tendency for the applicator to leak and then soak the wearer's back with herbicide.

E. Power Sprayers

These sprayers are a good investment and ideal for large areas. These sprayers have a pump and regulator to provide constant pressure and a more uniform spray delivery. The spray tank may consist of plastic, fiberglass, stainless steel, galvanized steel, or epoxy-lined steel. These systems usually have

a gun-type nozzle for spot treatments and sometimes a boom for broadcast applications. The disadvantages of power sprayers are similar to those of the backpack sprayers and pressurized canister sprayers.

F. Wick-Wipers

Various makes and models of "wiper" applicators are available, primarily for use in applying a 33 percent solution of glyphosate. Wick-wipers allow accurate placement of herbicide on unwanted plants and avoid problems with spray drift.

G. Granular Applicators

These applicators spread granular herbicide formulations of and fertilizers. Two general types of granular applicators are available to homeowners:

1. The gravity, or drop-type applicator, is best used on level turf areas or on level areas where the soil has been firmed. Use of this type of applicator on a steep hill or loose soil conditions will result in non-uniform applications.
2. The cyclone or whirlybird will operate under almost any type of condition but is affected by wind and tall vegetation.

Note: It is best not to use the same sprayer for both insect and weed control. Some herbicides, such as 2,4-D, are difficult to completely remove from sprayers. If you do decide to use the same sprayer, be sure to wash it with detergent after herbicide use. Then, fill the tank and prime the system with an ammonia solution (1 quart of household ammonia in 10 quarts of water) and let stand. After 12 to 24 hours, rinse and purge the sprayer with clean water until the ammonia solution is totally removed.

VI. Sprayer Calibration

Many people do not calibrate their application equipment and then wonder why their weed control efforts fail. Calibration for an herbicide treatment differs from an insecticide or fungicide treatment. Insecticides and fungicides are applied at a specific concentration while herbicides are applied at a specific rate of product per unit area (e.g., ounces per 1,000 sq ft). Therefore, the amount of water used is not as important as the amount of herbicide used per unit area as long as adequate coverage is obtained with the water used.

Factors affecting the calibration of a sprayer include pressure, nozzle size, condition, number, as well as the viscosity of the spray, and the speed at which the area is covered. Variable pressure will cause variable sprayer. Therefore, maintaining constant pressure or using a pressure regulator will facilitate a consistent application. The rate of speed that an area is covered should be held as constant as possible to improve the accuracy of the application. Gardeners using hand-held or hand-operated sprayers will operate their sprayers at different pressures and cover areas at different speeds. Therefore, calibration should be done by the individual who will be making the application.

A. Calculating Your Sprayer

Any kind of sprayer can be calibrated by using the following steps:

1. Check the operation of the sprayer. Check for a clogged nozzle and hose, rust in the tank, and leaks. Thoroughly clean and repair the sprayer before calibrating the sprayer.
2. Mark off 100 square feet. (You may want to use 1,000 square feet for more accurate calibration.) Use a string or garden hose to mark off the area.
3. Add a known quantity of water to the sprayer that is sufficient to cover the marked off calibration area.
4. Spray the calibration area exactly as you would spray herbicide. Be sure to walk the same speed and use the same pressure as you would when spraying the herbicide. Remember, you only need to lightly wet the plants. Don't spray until the water drips off.

Note: Many recommendations are given per 1,000 square feet. If 100 square feet is used for calibration, multiply the difference remaining in the tank by 10 to calculate the amount of water that would be required to cover 1,000 square feet.

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5. Measure the remaining water in the tank. The difference between what you originally added to the tank and what remains is the amount of water required to cover 100 square feet (or 1,000 square feet).
   - If you applied 18 fluid ounces to a 100 square foot area, 180 fluid ounces or 1.4 gallons of water to cover a 1,000 square foot area.
   - Add the recommended rate of chemical to the amount of water needed to spray 1,000 square feet.
   - Apply the herbicide by walking the same speed and using the same pressure as when you calibrated.

Example: You have sprayed 13 ounces on the 100 square feet.

13 oz x 10 = 130 oz (about 1 gallon) per 1,000 square feet

Add the recommended amount of herbicide to 1 gallon of water to spray the 1,000 sq ft area.

B. Granular Applicators

These can be calibrated in a similar way as sprayers, but the applicator must use the herbicide granular material in the calibration process. A cement or asphalt driveway or a large plastic canvas sheet can be used to catch the herbicide as it is distributed by the spreader. The surface area of the drive or canvas sheet is measured. Then the applicator is operated in the same manner that it would be operated for the actual application. After completing this calibration application, the granules are swept up and weighed.

Adjustments are made to the applicator until the desired amount is being applied in a consistent manner. The operator should note the setting on the applicator so that calibration is not required before each time an application is made. However, calibration should be done whenever the source of the material changes, or at the beginning of the season each year.

VII. Tree Stump Removal

When trees are cut from a landscape, removal of the remaining stumps often becomes a difficult problem.

A. Mechanical Removal

Using heavy equipment, such as a back hoe, to remove a tree stump can be expensive. It also might result in unacceptable damage to turf, ornamentals, or other adjacent vegetation. Failure to remove the complete stump and roots will often result in a proliferation of new shoots.

Some homeowners use an axe or chain saw to cut away stumps. This generally requires a lot of time and energy but can be successful if the trunk is not too large, and if the roots can be removed.

B. Chemical Treatments

Treating tree trunks with an appropriate herbicide concentrate before cutting (or treatment of live stumps after cutting) will kill stumps and roots, and stop sprouts from developing. Use caution when treating trunks or stumps with herbicides. Some herbicides may leach into the root zone of nearby plants. Application of herbicide is usually best accomplished with a paint brush rather than a sprayer. A dead stump will normally decompose in 1 or 2 years. Then, the rotted wood can easily be removed by hand.

VIII. Noxious Weeds

> *"Noxious weed" means kind of species of any plant having the potential to cause injury to public health, crops, livestock, land or other property, and which is designated as noxious by the director.*
>
> Chapter 24, Title 22, Idaho Code, Noxious Weeds

Noxious weeds are weeds that have been declared by law to be noxious. Property owners must not allow noxious weeds to go to seed or propagate on their land. Idaho, through the State Department of Agriculture, determines weeds to be listed as noxious and provides counties the power to administer the law.

Procedures have been set by law and rules promulgated by the State Department of Agriculture which form noxious weed districts. These districts direct noxious weed control efforts within in their jurisdiction. These efforts may include handling complaints, entering property through an established procedure to control noxious weeds, attaching claims against prop-

erty to cover control costs, and cooperating with other agencies and organizations in controlling noxious weeds. The weeds listed in Table 4 are officially designated and published as noxious.

> *It shall be the duty and responsibility of all persons and nonfederal agencies to control noxious weeds on land and property that they own, in accordance with this chapter and with rules and regulations promulgated by the director of the Department of Agriculture.*
>
> Chapter 24, Title 22, Idaho Code, Noxious Weeds

Table 4. Designation of Idaho noxious weeds.

Black henbane (*Hyoscyamus niger* L.)
Buffalobur (*Solanum rostratum* Dun.)
Canada thistle [*Cirsium arvense* (L.) Scop.]
Dalmatian toadflax [*Linaria dalmatica*) (L.) Mill.]
Diffuse knapweed (*Centaurea diffusa* Lam.)
Dyer's woad (*Isatis tinctoria* L.)
Eurasian watermilfoil
Field bindweed (*Convolvulus arvensis* L.)
Hoary cress [*Cardaria draba* (L.) Desv.]
Johnsongrass [*Sorghum halepense* (L.) Pers.]
Jointed goatgrass (*Aegilops cylindrica* Host)
Leafy spruge (*Euphorbia esula* L.)
Matgrass (*Nardus stricta* L.)
Meadow knapweed (*Centaurea pratensis* Thuill.)
Milium (*Milium vernal* Bieb.)
Orange hawkweed (*Hieracium aurantiacum* L.)
Musk thistle (*Carduus nutans* L.)
Perennial pepperweed (*Lepidium latifolium* L.)
Perennial sowthistle (*Sonchus arvensis* L.)
Poison hemlock (*Conium maculatum* L.)
Puncturevine (*Tribulus terrestris* L.)
Purple loosestrife (*Lythrum salicaria* L.)
Rush skeletonweed (*Chongrilla juncea* L.)
Russian knapweed [*Acroptiloa repens* (L.) DC.]
Scotch broom [*Cytisus scopariu* (L.) Link]
Scotch thistle (*Onopordon acanthium* L.)
Silverleaf nightshade (*Solanum elaeagnifolium* Cav.)
Skeletonleaf bursage (*Ambrosia tomentosa* Nutt.)
Spotted knapweed (*Centaurea maculosa* Lam.)
Syrian beancaper (*Zygophyllum fabago* L.)
Tansy ragwort (*Senecio jacobaea* L.)
Toothed spurge (*Euphorbia dentata* Michx.)
White-top [*Caradaria draba* (L.) Desv.]
Yellow hawkweed (*Hieracium pratense* Tausch)
Yellow starthistle (*Centaurea solstitialis* L.)
Yellow toadflax (*Linaria vulgaris* Mill.)

Further Reading

Books

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Booklets and Pamphlets

University of Idaho Extension

PNW 320 Calibrating and Using a Backpack Sprayer

CIS 1041 Conduct Your Own Garden Research

CIS 1019 Pesticides for the Home Garden and How to Use Them

BUL 775 Planning an Idaho Vegetable Garden

CIS 888 Weed Control in Lawns

EXT 726 Weed Control in the Home Garden

Published 1993. Revised 1996.

Chapter 15

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Chapter 15
Turfgrass Establishment and Management

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INTRODUCTION

Turfgrasses enhance the appearance and utility of home landscapes, parks, golf courses, sports fields, and other greenbelt areas. Lawns improve urban environments by reducing erosion, temperature, noise, dust, glare, and carbon dioxide. Grass is so efficient at converting carbon dioxide to oxygen that an area 50 feet × 50 feet generates enough oxygen to meet the needs of a family of four. A lawn also provides the setting and unity for other landscape elements, such as buildings, patios, water features, trees, shrubs, and flowers.

Everyone knows what a healthy lawn should look like—a uniformly green carpet free of insects, weeds, and diseases. Establishing and maintaining such a lawn is a long-term commitment of labor, money, and other resources. The homeowner faces many decisions. What type of lawn is needed? Will it be a showplace, a recreational area, a backdrop for other landscape plants, or a combination of the above? What level of maintenance will be provided? Will the family perform the maintenance or hire it out? High maintenance usually means greater expenditures of time and/or money. Are both available?

Successful establishment and maintenance of a healthy lawn requires knowledge of climate, soils, and availability of water and other resources. Climate, soils, and topography vary greatly across Idaho. Climate depends on location, ranging from the warm, arid south to the cooler, semiarid north. Idaho's natural vegetation ranges from sagebrush and bunchgrasses in the south to evergreen forests in the north and at higher elevations.

SOIL AND SITE CONSIDERATIONS

Evaluating the site

Assess your site's limitations. Lack of light or water, poor drainage, or shallow or compacted soils can limit a site's ability to produce quality turfgrass. Turf needs at least 4 hours of direct sunlight a day to thrive. In general, it is best to have at least 1 foot of soil over any hardpan (caliche), dense clay, or gravelly subsoil. If less than a foot of soil exists over hardpan or dense clay, drainage problems and restricted root growth will result in turf failure. On the other hand, the limited water- and nutrient-holding capacity of gravelly subsoil will also cause turf to fail. In very low-light areas, on steep banks, and where soil and/or water are inadequate, ground covers, meadow grasses, low-growing shrubs, and mulch are more realistic alternatives to mowed turf.

Soil texture and structure

Sand, silt, and clay describe the three basic sizes of soil particles. A soil's percentage of sand, silt, and clay determine its texture. Soil structure refers to the arrangement of soil particles into aggregates. For more information, see chapter 5.

Lawns can grow on essentially any soil texture, from sand to clay, but a fine sandy silt loam is ideal. Sandy or gravelly soils make it difficult to maintain nutrition and moisture levels, while compacted clayey soils can have water infiltration and drainage problems.

Both sandy and clayey soils can be improved by regular additions of organic matter. Humus (finished compost) modifies soil structure to improve aeration and drainage. In addition, humus can improve a soil's ability to hold nutrients and water, and it is a food source for beneficial soil microorganisms.

Soil pH and fertility

A soil analysis performed prior to lawn establishment will provide valuable information about existing nutrients, pH, and organic matter. Lawn grasses flourish at a soil pH between 6.0 and 7.5. A pH outside of this range can lead to chronic micronutrient deficiencies and poor growth. Soil pH can be adjusted slightly. If adjustment is needed, it's best to do so during soil preparation, before seeding or sodding. See chapter 5 for more information.

Phosphorus is essential for root development. Unlike most nutrients, surface-applied phosphorus does not move readily down into the soil profile, so it's best to incorporate it into the soil before seeding or sodding (see "Soil Preparation," page 15-5).

CHOOSING A TURFGRASS

Cool-season grasses can withstand Idaho's cold winters and perform well under most conditions found in the state. Most turf species have been hybridized to produce cultivars (cultivated varieties) with specific characteristics, such as fine texture, high density, and dark green color; early spring green-up; tolerance to cold, drought, or traffic; or resistance to insects and diseases.

During the intense heat of summer, cool-season grasses often turn tan and go semidormant. This condition is a natural survival mechanism. Once the heat of summer ends and more water is available, the grass will resume growth and become green again.

Quick turfgrass identification

Bluegrass
- Fine blades, canoe-shaped blade tip
- Rhizomatous growth habit

Ryegrass
- Fine blades, upper side heavily veined, shiny lower leaf surface, pointed tip
- Bunch-type growth

Tall fescue
- Fine to medium-sized blades
- Upper side heavily veined, lower leaf surface smooth with prominent midvein, pointed tip
- Most have a bunch-type growth habit

Fine fescue
- Very fine needle-like blades, pointed tip
- Bunch-type or rhizomatous growth, depending on species

Selecting a turfgrass depends on site characteristics and on how the lawn will be used (e.g., playing field or perfect lawn). Grass varieties are available for almost any situation. For lawns that receive a large amount of heavy play or foot traffic, turf-type tall fescue or perennial ryegrass is often used. If many trees are present, select grasses that can withstand shade, such as fine fescue. Some recently introduced turfgrasses are more xeric, using 50 percent less water than older varieties. In some situations, a mixture of species may be the best option. Table 1 lists cool-season grass species and many cultivars. See the sidebar above for quick turfgrass

Table 1. Cool-season turfgrass cultivars for Idaho.

Type of turfgrass	Cultivars
Kentucky bluegrass	Award, NuGlade, Bluechip Plus, Everglade, NuDestiny, Nublue Plus, Liberator, Rugby II, Adelphi, Fylking, Parade, Galaxy, Park, Pennstar, Baron, Liberty, Majestic, Touchdown, Freedom, Newport, Victa, Nuget, Challenger, Kenblue, Plush, Chateau, New Blue, New Star, Washington, Classic
Perennial ryegrass	Accent, Caddieshack, Goalkeeper, Top Gun, All Star, Diplomat, Derby, Evening Shade, Fiesta II, Manhattan II, Omega II, Ovation, Pennant, Regal, Saturn, SR 4000, Troubadour, Palmer, Prelude, Patriot II, Yorktown II
Turf-type tall fescue	Inferno, NoNet, Quest, Summer, Watersaver (RTF), Arid 3, Crossfire, Falcon, Jaguar II, Monarch, Mustang, Rebel II, Titan, Bonsai, Twilight
Fine fescues:	
Chewings fescue	J-5 chewings fescue, Banner, Barialia, Cascade, Jamestown
Creeping red fescue	Audubon, Pennlawn, Rainer, Ruby, Wintergreen
Hard fescue	Ecostar Plus, Rescue 911, Biljart, Durar, Reliant, SR 3000, Scaldi
Sheep fescue	Marco Polo

identification. See table 2 to compare characteristics of different turf species.

Note: Consult your local University of Idaho Extension office for recommended grass species or cultivars for your area.

Kentucky bluegrass

Kentucky bluegrass is probably the most common cool-season grass for lawns, and it is part of most grass mixtures. A monoculture (pure stand) of Kentucky bluegrass is not recommended because of insect and disease problems.

Kentucky bluegrass has a high fertility requirement and a high water requirement. It does not tolerate shade. Kentucky bluegrass is slow to germinate and establish, but it is good at repairing damaged turf areas because of its ability to spread via rhizomes. However, it can spread into flower beds that border lawn areas and is a strong thatch former.

Tall and fine fescues

Turf-type tall fescue. Tall fescue is usually planted as a monoculture or mixed with fine fescues. Newer turf-type tall fescue cultivars, especially dwarf cultivars, are thinner bladed than older varieties and, once established, look very similar to Kentucky bluegrass. These turf-type fescues are not the same as coarse pasture fescues.

Tall fescue is resilient and well adapted to a wide range of soil conditions. It tolerates heat and drought better than most cool-season turfgrasses due to its deep root system (4 to 6 feet). Its fertility requirement is medium, and its water requirement is medium. Many tall fescue cultivars contain fungal endophytes, which ward off insect attacks—a major benefit where turf insects proliferate (see sidebar above).

Tall fescue tends to withstand traffic and heavy use and is often used on football and other playing fields. It does not tolerate low mowing. Most tall fescue cultivars are bunchgrasses; they do not spread by rhizomes and thus do not form thatch or invade flower beds. In recent years, a few spreading turf-type cultivars have been developed.

Endophytes

Perennial ryegrass and most turf-type tall fescue cultivars live in a symbiotic (mutually beneficial) relationship with endophytes. These naturally occurring fungi produce a wide range of chemicals with insecticidal properties, the most important being alkaloids. These chemicals move within the grass plant, giving it built-in defense against billbugs, sod webworms, army worms, and chinch bugs. Some resistance to nematodes has also been documented.

Different species of endophytes infect different grasses. *Acremonium foliar* infects perennial ryegrass, while *A. coenophialum* infects tall fescue. Endophyte levels vary, depending on the grass cultivar.

Table 2. Turf characteristics.

Characteristic	Turf-type tall fescue	Kentucky bluegrass	Bluegrass/Ryegrass mix	Fine fescue
Leaf texture	Fine to medium	Fine	Fine with high luster	Very fine
Growth rate	Slow to medium	Medium	Medium	Slow
Rooting depth	Very deep (4–6 ft)	Shallow (6–12 inches)	Medium (18 inches)	Deep (2–3 ft)
Thatch production	None to low	High	Varies[a]	Low to medium[b]
Water requirements	Medium	High	High	Low to medium
Fertilizer requirements	Medium	High	High	Low to medium
Insect resistance	High	Medium	High	High
Disease resistance	High	Low to medium	High	High
Drought tolerance	High	Low to medium	Low to medium	High
Heat tolerance	High	Low to medium	Low to medium	Low
Shade tolerance	Medium	Low	Low to medium	High
Cold tolerance	Medium to high	High	Medium to high	Medium to high
Traffic tolerance	High	Medium	High	Medium

[a]Thatch production depends on the percentage of bluegrass in the mix. Bluegrass is a strong thatch producer, while perennial ryegrass produces none.

[b]Fine fescue thatch production depends on the grass variety and increases with higher fertility levels.

Fineleaf fescues. Fine fescues include creeping red fescue, chewings fescue, hard fescue, and sheep fescue. These species are often added to mixtures with other cool-season grasses to provide drought tolerance and disease resistance. These grasses have the narrowest leaves of any lawn grass. Sheep fescue is an Idaho native grass with a blue-green appearance.

Fine fescues perform best in shady conditions. Seed mixes for moderate shade should contain 20 to 30 percent fine fescue. These grasses are adapted to well-drained, infertile soils. Their fertilization requirements are low to medium, and their water requirement is low to medium.

Fine fescues are excellent for overseeding lawns to improve turf quality. On slopes, they often are left unmowed to create a meadow effect.

Creeping red fescue has a spreading rhizomatous root system that will easily cover open soil areas to create a lawn. Chewings fescue is a bunchgrass that does not spread. It must be planted thickly to ensure dense, even turf. Sheep fescue and hard fescue are also bunch types; they make excellent turf, have extensive root systems, and are very drought tolerant.

Perennial ryegrass

Turf-type perennial ryegrass germinates and establishes rapidly, often within 6 days. This bunchgrass is extremely wear tolerant, producing beautiful lawns that do not form thatch.

Ryegrass blends well with other grasses and adds insect resistance due to its symbiotic relationship with endophytes. Mixtures of perennial ryegrass and Kentucky bluegrass create a turf far superior to either species grown alone.

Like Kentucky bluegrass, perennial ryegrass requires medium to high fertility levels. It has a medium water requirement. Ryegrass leaves are fibrous and require a sharp mower blade to avoid shredding or tearing the grass.

SITE PREPARATION

Preplant weed control

If perennial weeds or undesirable grasses are present, preplant weed control is critical. A nonselective herbicide, such as one containing glyphosate, can be used. More than one application may be necessary for some perennial weeds. Follow herbicide label directions carefully.

Soil preparation

Regardless of whether a lawn is established by seeding or sodding, the key to success is proper soil preparation. Following new home construction, debris is often left in the lawn area. Materials such as cement, wood, bricks, nails, sand, and gravel create unfavorable conditions for lawn grasses and usually result in dry spots. They also block root development and can cause mowing hazards. Remove these materials prior to grading and lawn installation.

If possible, remove rocks from the upper 2 inches of soil to provide a uniform medium for grass roots. If tree stumps or other organic debris are present, remove them rather than covering them with soil. Buried stumps and logs create soil depressions as they decay, often accompanied by fairy ring fungus and other fungi (see “Diseases,” page 15-18).

The only chance to modify soil structure and drainage is before lawn establishment. Apply 1 to 2 inches of humus before rototilling. Humus can be purchased by the bag or in bulk at nurseries. For more information on composting and producing humus at home, see chapter 8. If a soil test indicates that fertilizer is needed, apply it now, especially if you are using an organic or slow-release fertilizer, as these products need time to break down. This is also the time to adjust pH, if needed. See chapter 5 for more information. Rototill all amendments into the top 8 to 10 inches of soil.

Contour and slope are determined by the existing landscape and by structures such as buildings, walks, and driveways. Slope the lawn away from the house. Minor surface irregularities will become permanent after grass roots have locked soil particles together. After establishing the rough grade, rake and smooth the area to fill holes or depressions and reduce high spots. The smoother the area, the better its appearance. Allow 2 to 4 weeks for settling before planting the lawn. Two or three soaking and drying periods during this time will facilitate settling.

Installing a sprinkler system

If an in-ground system is desired, install it after final grading and smoothing, but before seeding or sodding.

ESTABLISHING A LAWN BY SEEDING

Seed selection

Always purchase high-quality seed. Although seeding is an inexpensive way to produce a lawn, the cost of seed is a small portion of the total cost of establishment. Quality seed costs a little more, but it is worth it. Saving a few dollars by compromising on seed quality will only jeopardize your overall investment in your lawn. Purchase seed that is labeled as containing "0% weed seed." Why plant weeds if you don't have to?

Certified seed. Buying certified seed is a good practice. Certification ensures that a seed package contains quality seed of the cultivar named on the label. When certified seed is sold in bulk, a blue certification label is attached to the seed bag.

Seed package labels. Seed package labels contain valuable information to help you choose wisely (figure 1). The seed analysis enables you to determine how well the seed should perform and its cost effectiveness compared to other brands. The following terms are used on grass seed labels:

- **Pure seed**—percentage (by weight) that is seed of the specified crop
- **Germination**—percentage of viable (live) seed
- **Inert matter**—percentage (by weight) of chaff, dirt, trash, and anything else that is not seed
- **Date of test**—date of the seed analysis; it should be within the past 15 months.
- **Weed seeds**—percentage (by weight) of weed seeds in the sample and the number of noxious weed seeds present (**Note**: It is against Idaho law to sell seed containing noxious weed seeds. If the label lists noxious weeds, do not purchase the seed and report it to the Idaho Department of Agriculture.)
- **Other crop seeds**—percentage (by weight) of crop seed other than the crop specified. For example, tall fescue seed might include some orchardgrass and annual ryegrass seed. Kentucky bluegrass might include bentgrass, annual ryegrass, tall fescue, or perennial ryegrass seed.

Comparing cost. When comparing seed lots of similar quality, calculate the cost of Pure Live Seed (PLS). Pure Live Seed indicates the percentage of seed that will germinate and produce the expected lawn quality. To determine PLS, multiply the

How much do you need?

Seeding and fertilizer rates often are given as amounts per 1,000 square feet. Follow the steps below to calculate how much to purchase.

1. **Estimate lawn size**. Use one of the following methods.
   - Use a measuring wheel to measure the lawn area.
   - If the lawn is a small square or rectangle, multiply length by width to get the square footage. For example,
     10 ft × 20 ft = 200 sq ft.
   - If you know the lot size in acres, multiply by 44,000 to get an approximate square footage. For example,
     0.5 acre × 44,000 = 22,000 sq ft.
     Don't include space occupied by nonlawn areas, such as the house or flower beds. In this example, if only one-quarter of the area is lawn, then the lawn is 5,500 sq ft (22,000 sq ft × 0.25 = 5,500 sq ft).
2. **Calculate the amount of product needed**. Multiply the seeding or fertilizer rate (per 1,000 square feet) by the lawn size found in step 1. Then divide by 1,000. For example,
   5 lb × 5,500 sq ft ÷ 1,000 = 27.5 lb.
   This is the amount to purchase.

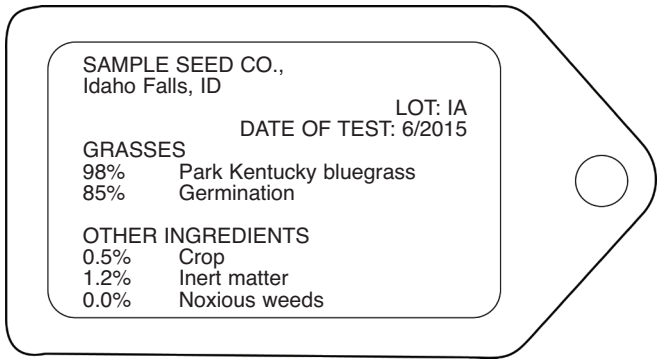


Figure 1. Sample seed label.

germination percentage by the percentage of pure seed and then multiply by 100. For example:

Germination = 85%
Purity = 98%
Calculation: 0.85 × 0.98 = 0.833
0.833 × 100 = 83.3% PLS

Now, to obtain the cost per pound of PLS, divide the price per pound of the seed by the PLS. For example:

Price per pound = $4.00
PLS = 83.3%
Calculation: $4.00 ÷ 0.833 = $4.80/lb

Seeding rate

Seeds vary in size, weight, and growth rate, depending on the grass species. For this reason, seeding rates vary. Follow directions on the seed package or the general guidelines in table 3. Calibrate the spreader to deliver the appropriate seeding rate. See the sidebar "How Much Do You Need?," page 15-6, to calculate how much seed to purchase.

When to sow

It can take 4 to 6 months to thoroughly establish a lawn from seed. The optimum time for seeding turf is in the fall, from mid-August through mid-September (earlier at higher elevations). Completing seeding during this time frame allows the grass to become well established before winter.

Fall seeding is much more successful than spring seeding for several reasons. Warm days and cool nights in the fall provide ideal conditions for seedling growth. Also, there is less weed competition. The first heavy frost will kill tender broadleaf weeds and summer annual grasses that germinate with the grass seed. By spring, lawns seeded the previous fall will be well rooted and have good top growth, making them drought- and heat-tolerant by summer.

Table 3. Seeding rates for cool-season turfgrasses.

	Seeding rate	
Species	**(lb/1,000 sq ft)**	**(lb/acre)**
Kentucky bluegrass	1–2	40–80
Perennial ryegrass	4–6	160–240
Fine fescue	3–5	120–200
Tall fescue	4–6	160–240

In some dry or short-season growing areas of Idaho, grass seed is sown on top of the soil just before winter snows to take advantage of the insulating capacity of snow and moisture from snow melt. The grass will germinate in spring once the snow recedes.

Spring seeding (April through May) is used where rain or early frost prevents soil preparation and seeding in the fall, or if the fall seeding time is missed. Seed as soon as the ground is dry enough to be worked without damaging soil structure. Germination periods depend on soil temperature. For example, an April sowing will take longer to germinate than a May sowing. If seed is sown too early, when the soil is cold and damp, germination will be slow and irregular.

Spring-seeded turf may face strong competition from germinating weeds in some areas. If practical, wait until annual weed seeds germinate, cultivate the soil to kill them, and then sow the grass seed. This option is feasible if seeding can still be done in May to allow the lawn to establish before the heat of summer.

Establishing turfgrass by seeding in midsummer (July and August) is difficult due to high temperatures, evaporation, and drought conditions. Summer seeding can be successful only if supplemental irrigation is available. The seeded area must be kept moist during the entire germination period. If the surface dries before seedlings emerge, the percentage and rate of germination will be severely reduced.

Seeding methods

Only very small spots can be effectively seeded by hand, as it is difficult to distribute seed evenly using this method. Lawns usually are seeded with a drop spreader or rotary (cyclone) spreader. Drop spreaders are more accurate than rotary spreaders. They also work better along driveways, sidewalks, and flower beds because they do not drop seed where it is unwanted.

To ensure uniform distribution of seed, divide the recommended amount of seed into two equal parts. Sow half of the seed in one direction and the second half perpendicular to the first. Lightly rake the seed into the soil surface (about ¼ inch). Do not rake heavily, as doing so will cover the seed too deeply.

You can enhance germination by using a roller to improve seed-to-soil contact.

Top-dressing seeded areas

Grass seed can take 1 to 3 weeks to germinate, depending on species. Top-dressing means applying a thin layer (⅛ to ¼ inch) of some material to the surface of a newly planted seedbed to encourage germination. A layer of top-dressing reduces seed displacement by wind, rain, and irrigation. It also prevents birds from eating seeds, raises humidity at the soil surface, and reduces soil crusting.While top-dressing is not essential, it is helpful, especially on sloped sites. Humus, peat moss, chopped straw, dried grass clippings, and clean topsoil are commonly used for top-dressing. Choice of material depends on the site, availability, cost, and ease of handling.

Watering and fertilizing

Failure to provide sufficient moisture is a major cause of unsuccessful turf establishment. After seeding, the top 1 inch of soil must be kept consistently moist. If rainfall is inadequate, irrigate a short amount of time twice each day for the first 3 weeks. Summer-seeded turf may require three or more irrigations per day. After seedlings have grown enough to mow, reduce irrigation frequency (see "Irrigation," page 15-12).

If a fertilizer was applied before planting, there usually is no need to fertilize a lawn before it is 4 to 6 weeks old. If no fertilizer was applied prior to seeding, use a cyclone spreader to apply a half-rate application of starter fertilizer (e.g., 5-10-10 or 15-15-15) after the lawn is mowable.

Mowing

Start mowing as soon as the grass is tall enough to cut (more than 2 inches). Frequent mowing helps control annual weeds and limits clipping accumulation, which might smother the new turf.

Set the mower at the proper cutting height for your grass species, and keep the mower blade sharp. See table 4 for recommended mowing heights. Follow the one-third rule; remove no more than one-third of the leaf growth at each mowing. Avoid mowing when it is muddy, as mud on mower wheels may adhere to seedlings and pull them out of the ground.

Table 4. Recommended mowing heights.

Species	Height (inches)[a]
Kentucky bluegrass	1.5–3
Perennial ryegrass	1–2
Fine fescue	2–3
Tall fescue	2–4

[a]In spring and fall, use the lower end of the range. Use the higher end of the range in summer.

Weed control

To avoid turf damage, do not spray weeds until the new lawn is at least 6 weeks old. Following fall seeding, the first heavy frost may eliminate most weeds, thus reducing the need for herbicides.

Overseeding

The potential for a lawn to provide a quality surface depends on the species and cultivars of grasses present. The best maintenance program is not likely to produce a quality lawn if inferior grasses dominate the stand. Over time, most lawns eventually become invaded with less desirable grass species, such as bentgrass and pasture fescues. Periodic infusion of new, improved cultivars into an existing turf will increase the chances of maintaining a high-quality lawn. Reseeding bare spots or thickening up sparse turf are additional reasons to overseed. Overseeding is usually done in late summer or early fall. However, small areas can be overseeded at any time, as long as they are kept moist during germination.

Spot seeding. If seeding a small area, work the area with a hard-tined rake or shovel. If the area is compacted, add some humus and incorporate thoroughly. Mix fertilizer into the soil, if needed (see "Soil Preparation," page 15-5), and sow the grass seed. Rake the area lightly following seeding to incorporate the seed into the soil. This will increase soil-to-seed contact and enhance germination.

Changing grass species. Changing to a more desirable grass species without removing the old grass is a type of overseeding. First, use a nonselective herbicide such as glyposate to kill the old lawn. More than one application may be necessary.

After the lawn dies, mow as closely as possible. Then dethatch the area with a vertical mower or dethatching machine (see "Thatch Management,"

page 15-11). Rake up the accumulated debris, and dethatch again in a perpendicular direction. Rake up the remaining debris.

Keep in mind that if a soil problem existed before the original lawn was seeded (e.g., dry, compacted soil), the problem will remain after the new turf is seeded. Where underlying soil problems exist, complete renovation may be needed (see "Turf Renovation," page 15-17).

Finally, seed the area with the new grass species. Rake lightly to incorporate the seed into the soil. Apply a thin layer (⅛ to ¼ inch) of topsoil or humus and begin watering as you would a newly seeded lawn.

ESTABLISHING A LAWN BY SODDING

Benefits of sod

Sod offers the instant beauty of a lush, weed-free lawn that can be used in as few as 3 weeks after installation. Sod may be the solution for a family in a new home where children need a safe, clean place to play, or where a steep slope increases the risk of erosion. Other advantages of sodding include the following: (1) an instant increase in property value, (2) elimination of the need for top-dressing, (3) reduced need for weed control and water during establishment, and (4) reduced effort to nurture a new lawn to full establishment.

On the other hand, sod costs about six times more than grass seed, and installion may involve additional expenses, such as labor to remove the old turf and install the sod.

Purchasing sod

Several types of sod are available for residential landscapes, with each type suited to a particular environment or use. The most common types are Kentucky bluegrass blends, bluegrass–perennial ryegrass mixtures, tall fescue-fine fescue mixtures, and turf-type tall fescue monocultures. If possible, examine the sod before ordering. Sod should be of uniform color and thickness, with minimal weeds.

Preparing for sod delivery

Prepare the site before scheduling delivery of the sod. Soil preparation for seeding and sodding are essentially the same (see "Site Preparation," page 15-5). Do not skimp on soil preparation or site grading.

Do not lay sod on dry soil. Even if sod is watered immediately after installation, root growth will be hindered. Water to a depth of 6 to 8 inches 24 to 48 hours before installation. It is important to allow enough time between watering and sod installation so that the site is not muddy when installation begins.

Sod is heavy; it weighs about 50 pounds per 10 square feet. Piece size varies, depending on the cutting machine used. Pieces typically are 18 inches wide × 80 inches long or 24 inches wide × 60 inches long. Each piece makes up 10 square feet. Sod is shipped on wooden pallets, each stacked with 500 to 700 square feet of grass.

Be on-site when the sod arrives so that the pallets can be positioned to minimize the distance that sod rolls must be carried. Examine several rolls before accepting the sod.

Plan to lay the sod immediately. If you must wait a day, keep the rolls moist (not soggy) and in a shaded location. For a delay of up to a week, it is best to unroll the sod on a plastic tarp or cement to avoid having it root into itself or into the soil where it's stacked. Make sure to keep the sod moist.

Sod installation

Sodding can be successful during every season except winter. Sodding in spring or fall, when cool-season grasses grow rapidly, allows quick rooting. In dry areas or during hot weather, frequent irrigation is necessary.

The easiest way to install sod is to hire a landscape contractor, but you can save money by doing the job yourself. Be prepared to squat or kneel on the soil surface as you work. Wearing a pair of rubber knee pads is a good idea.

Handle sod with care to avoid tearing or excessive stretching. Lay the first strip along a straight edge, such as a driveway or sidewalk. If no straight edge is available, lay sod at a right angle to a curve or use a string to establish a straight line. On the second and succeeding rows, stagger the joints similar to the way bricks are laid. Butt joints tightly together to prevent roots from drying out, but do not overlap pieces.

Water within 30 to 60 minutes of laying the first piece. If you wait until the whole lawn has been sodded, the first-laid strips may dry out. Continue to

lay sod and water previously sodded sections until installation is complete.

Use a sharp knife to cut sod to fit curves, edges, and sprinkler heads. Try to avoid using short or narrow leftover pieces, as they tend to dry out rapidly. If an edge does not abut a curb, sidewalk, or another strip of sod, mound soil against it to protect roots from drying.

When sodding a sloped site, start at the bottom and work upward. If the slope is steep, tack sod strips down with wooden pegs (available at construction supply stores). Leave the pegs in place until sufficient rooting has occurred to stabilize the soil and turf.

Rolling and watering

After all of the sod is laid, the lawn can be rolled. Rolling eliminates irregularities and establishes good contact between the sod and soil. Rollers are available at equipment rental centers.

Finally, water the sodded lawn thoroughly. Moisten the soil to a depth of 6 to 8 inches. Irrigate daily until the sod becomes rooted, about 10 days. Keep people off the lawn until the grass is well anchored, usually in 3 weeks.

After the sod is established, decrease irrigation frequency, but increase the amount of water per application. Deep but infrequent irrigations (10 to 12 inches deep once or twice a week) are best for developing a healthy, deep-rooted turf (see "Irrigation," page 15-12).

Mowing and fertilizing

Begin mowing after the sod is well rooted and growing. Make sure your mower blade is sharp. Use the one-third mowing rule; remove no more than one-third of the shoot growth at each mowing.

Ten days to 2 weeks after installation, apply a fertilizer with a high proportion of phosphorus and potassium (e.g., 5-10-10, 10-20-20, or 15-15-15) to encourage root growth. Organic and slow-release fertilizers should be applied during soil preparation to allow time for breakdown and nutrient release to occur. The fertilizer package will indicate the amount to apply (see "Fertilizing," page 15-14 and the sidebar "How Much Do You Need?" on page 15-6).

TURF MAINTENANCE

A healthy lawn should last many years if properly maintained by watering, fertilizing, mowing, and weed control. Dethatching, core aeration, top-dressing, and disease or insect control may be needed in some years.

It is difficult to dictate a one-size-fits-all lawn maintenance program, given Idaho's wide variety of microclimates and soil types. Basic practices are discussed in this chapter, but recommendations may need to be modified for your location. Talk with your local University of Idaho Extension educator for more information.

Mowing

Mowing is the most basic part of turfgrass maintenance since it influences a lawn's appearance and life span, as well as the need for other cultural operations. Mowing encourages lateral bud growth and tillering—the formation of aerial shoots from axillary buds located along the crown (figure 2). As tillering increases, the grass becomes finer, the sod gets thicker, and the turf's overall appearance is optimized.

On the other hand, mowing reduces photosynthesis and hence carbohydrate production. In the short term, it causes root growth to cease and increases water loss from cut leaf ends. Cut blades also create the potential for pathogen infection.

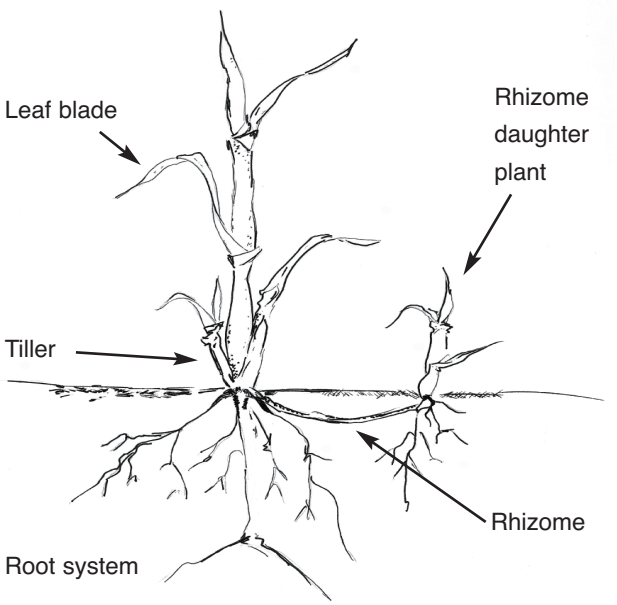


Figure 2. Anatomy of a grass plant. Drawing by Aubrey Stribling, University of Idaho.

Some grasses are more easy to cut cleanly than others. Perennial ryegrass and turf-type tall fescue, due to fibrous vascular bundles, are difficult to cut cleanly if the mower blade is not sharp. In contrast, Kentucky bluegrass has soft, succulent leaf blades that are easy to mow.

Always leave an unmowed strip next to ponds, streams, and lakes to reduce surface-water pollution.

Mowing frequency and height. Frequent mowing (every 3 to 4 days during active growth) is recommended to avoid removing more than one-third of the grass blades at any one time. Limiting foliage removal reduces the loss of photosynthesizing tissue. When growth slows due to heat or drought, mowing may be needed only once a week or every 10 days. In shaded areas, photosynthesis is less active than in the sun. In these areas, grasses grow more slowly and can be mowed less frequently as well.

Proper mowing heights for cool-season grasses are listed in table 4, page 15-8. During the heat of summer, raise the height of the mower blade by an inch. Longer grass blades trap moisture, shade the crowns, and promote a healthy, deep root system. Once temperatures cool, return to the lower recommended mowing height.

Scalping, or mowing lower than the recommended height, stresses grass and is not advisable at any time. A brown, scorched appearance often follows scalping, due to the removal of grass blades that otherwise would shade and protect the delicate crowns. Scalping ultimately results in decreased drought and heat tolerance, weed invasion, reduced photosynthesis, and shallow rooting.

Clipping removal. Clipping removal is optional. Clippings quickly decompose and, contrary to popular belief, do not cause thatch.

Mowing frequently and allowing the clippings to filter into the grass benefits the turf. Clippings supply organic matter and recycled nutrients, especially nitrogen. Decomposition of the succulent leaf tissues by soil microorganisms results in a constant, even supply of nutrients. Research indicates that as much as 20 to 30 percent of a lawn's fertilizer requirement can be supplied by grass clippings, thus eliminating one fertilizer application per year.

A mulching mower makes it easy to recycle clippings in place. However, any mower will work if the one-third rule is followed. If you mow infrequently and generate a thick layer of clippings, remove them, as they may suffocate the turf.

Thatch management

Thatch is the brown, fibrous, spongy layer located between the soil and green grass blades. Thatch is not caused by grass clippings. It is composed primarily of high-lignin materials such as roots and stems. As stems and roots grow, old tissues die and slough off, adding to the thatch layer. Soil microbes, earthworms, and other soil organisms decompose thatch.

Thatch accumulation is a natural process for rhizomatous grasses. Kentucky bluegrass is a prolific thatch former, while creeping red fescue is a medium thatch former. Bunchgrasses, such as perennial ryegrass, most turf-type tall fescue cultivars, and other fine fescues (chewings, sheep, and hard), do not develop thatch.

A thin layer of thatch (½ inch) is beneficial, as it reduces soil moisture evaporation and insulates the soil, thus moderating soil temperature. It also retains nutrients and protects roots from compaction by foot and equipment traffic.

Thatch that is more than ¾ inch thick is detrimental because it can restrict water, air, fertilizer, and pesticide movement into the grass and soil. During hot, dry weather, thatch can become dry and resistant to wetting (hydrophobic). Grass roots may grow into thick thatch instead of the soil, making the turf less heat-, drought-, and cold-tolerant. Many turf-eating insects and diseases find thick thatch a good place to call home. Finally, mowers tend to ride on top of deep thatch and do not cut the grass to the desired height.

Causes of thatch buildup. Thatch accumulates when conditions are good for organic matter accumulation and poor for its decomposition. Soil compaction contributes to thatch buildup because it affects soil oxygen levels and water movement.

Nitrogen fertilizer stimulates bacterial decomposition of thatch; consequently, insufficient fertilizing can cause thatch buildup. Conversely, overfertilizaton encourages thatch accumulation since it causes turf to grow (and die) faster than soil microorganisms can decompose the thatch. With excessive

fertilization, soils also can become saline, which reduces populations of earthworms and soil microbes.

Overuse of some pesticides, excessively wet or dry conditions, and cool weather also contribute to thatch buildup because they affect the population and activity of decomposers.

Controlling thatch buildup. The best way to prevent thatch buildup is to follow proper turf management practices. Use the right amounts of fertilizer and water to create conditions needed for moderate growth.

Clippings left on the lawn add nutrients as they decompose, invigorating microbial activity and accelerating thatch decomposition. Routine core aeration can also help, especially when cores are left to break down on the lawn (see "Core Aeration," page 15-16).

Top-dressing is another way to reduce thatch buildup. Periodic top-dressing with a thin layer (¼ to ½ inch) of soil or humus encourages beneficial microbial populations. Top-dressing often follows core aeration if the cores are not left in place. A drop spreader is usually used to top-dress. After top-dressing, rake the material into the turf.

Dethatching. Measure thatch depth by removing a wedge of turf, leaving the underlying soil intact. When thatch is more than ½ inch deep, dethatching may be needed. It may be necessary to dethatch every year until thatch is reduced to ½ inch. If thatch buildup is extreme (1½ to 2 inches deep), it may be wiser to remove the lawn and reseed or resod the area (see "Turf Renovation," page 15-17).

Dethatchers (vertical mowers) use cutting blades or tines that spin vertically to slice into the turf and soil surface, ripping the thatch. Dethatchers are available at equipment rental centers. After dethatching in one direction, remove the debris. Then dethatch in a perpendicular direction and remove the remaining debris.

Dethatching makes a lawn look rough and ragged in the short term. Top-dress after dethatching to level depressions. Follow with fertilization and irrigation to stimulate regrowth. Damage caused by dethatching may require overseeding, so fall is the preferred time for dethatching.

Irrigation

The goal of irrigation is to keep a lawn healthy when rainfall is not dependable. The key is to moisten the top 12 inches of the root zone, if possible. Kentucky bluegrass can develop a root system 6 to 12 inches deep, and perennial ryegrass can root 18 inches deep. Fine fescues develop roots 2 to 3 feet deep, and tall fescue roots can be 4 to 6 feet deep!

To irrigate properly, you must know your soil. Loamy soils are porous, yet retain moisture and are easy to irrigate. Clayey soils hold the most water, but can take a long time to absorb and release it. When watered deeply, clayey soils can hold water for a week or more. If irrigation is too frequent, they can become waterlogged. Sandy soils, on the other hand, are porous; they wet and drain quickly. Thus, they may need to be irrigated twice weekly to maintain comparable turf health.

Benefits of deep, infrequent irrigation. Watering deeply (10 to 12 inches) but infrequently (no more than once a week, twice on sandy soils) produces healthy turf. Light daily irrigations wet only the soil surface. Because roots grow where the soil is moist, shallow watering equals shallow-rooted turf. Shallow-rooted turf will not be able to withstand temperature extremes, pathogens, or insects, nor can it take advantage of nutrients deep in the soil. Deep watering also benefits landscape trees and shrubs, which suffer under a shallow watering regime.

Another advantage to deep watering is that it forces an exchange of soil atmosphere (in soil pores) with each irrigation. As water moves down the soil profile, oxygen is pulled into the soil. Improved soil aeration produces good root growth.

Watering infrequently also means more efficient water use because less moisture is lost to evaporation. Deep, infrequent irrigation can result in a water savings of approximately 45 to 55 percent per year compared to daily irrigation.

Finally, infrequent watering reduces weed populations because the area is not constantly moist. Many shallow-rooted weeds die when drought stressed.

To determine how deep your irrigation water goes, use a soil probe or shovel to check soil moisture after irrigation. At 10 to 12 inches deep, the soil should feel like a slightly damp, well-wrung-out

sponge—neither sopping wet nor bone dry. If the soil feels dry at the 10- to 12-inch depth, you are not watering long enough (see "Irrigation Challenges," page 15-14). Monitor irrigation each month until you learn how long it takes your soil, under your watering regime, to wet to this depth. Soil moisture sensors can more accurately determine moisture at the desired depth and control when irrigation begins and ends. They can greatly improve irrigation efficiency and lawn health.

When to irrigate. Learning to "read" your turf is an important skill. Watch for dry spots; they can indicate that the entire lawn needs water (see "Irrigation Challenges," page 15-14). Failure of grass blades to spring back when walked on, a grayish turf color, or lack of overnight dew formation indicates a need for irrigation. However, it is best to irrigate before these signs appear.

How long to irrigate. Rules of thumb for lawn watering are often given in gardening books. Example: "Turf uses an average of 1 to 2 inches of water per week." Reading this, homeowners often set sprinkler clocks accordingly. Unfortunately, water use varies day to day, due to differences in temperature, wind, humidity, and solar radiation (whether it is sunny or cloudy), so averages do not necessarily reflect the amount of water needed at any given time.

The best approach is to determine when irrigation is needed and then water long enough for moisture to reach a soil depth of 10 to 12 inches. As weather conditions change, adjust the frequency and amount of irrigation.

If you plan to water weekly using the "1 to 2 inches" rule of thumb, the amount applied should vary with the weather. While 2 inches of water per week may be needed during hot, dry weather in midsummer, less than ¼ inch may be consumed during cooler weather and rainy periods.

You can check how much water you apply using the "can method." Use four or five flat-bottomed cans of the same diameter (such as soup cans). The reason for using several cans is that nozzles often do not apply equal amounts of water over the entire spray pattern.

Start within a foot or two of the sprinkler head and place cans in a line to the end of the spray pattern. Leave an equal distance between cans. To determine the average amount of water applied over a specific period of time, add together the amount of water collected in all the cans. Then divide by the number of cans. For example:

Number of cans: 4
Watering time: 30 minutes
Total water collected in four cans: 2 inches
2 inches ÷ 4 cans = 0.5 inch of water applied over 30 minutes

How to irrigate. Early-morning (before sunrise) is the best time to water, since the turf will dry before evening. Night irrigation also uses water efficiently by reducing evaporation loss. However, it may increase disease problems if humidity and moisture remain high overnight. Daytime watering is not recommended, especially on hot or windy days, because of high evaporation rates and/or sprinkler drift. On hot, summer days, as much as half of sprinkler output can be lost to evaporation.

Regardless of soil type, apply water slowly to achieve good infiltration and prevent runoff. On clayey soils, it may take hours to apply the desired amount of water. Slow application of water is especially important on slopes, thatchy turf, and sites with clay or compacted soils.

Over-watering problems. If turf is squishy 12 hours after irrigating, or if you observe standing water, either you are overwatering or there is a drainage problem (or both). Yellowish-green grass or a thinning lawn may also indicate excessive irrigation.

Overwatering can leach nutrients beyond the turf root zone. Also, oxygen levels are low in saturated soils. Because roots develop best where oxygen is adequate, saturated soils induce shallow rooting. Low oxygen levels also slow the activity of beneficial soil organisms and encourage root rot pathogens that thrive under anaerobic conditions.

Water stress. Turf can wilt during drought or when underwatered. Just before wilting, the turf will no longer spring back after being walked on. As turf wilts, the blades turn grayish. Turf can survive a little water stress, but it is best to irrigate before these symptoms develop. If you notice these symptoms, water immediately. During severe drought conditions, cool-season grasses protect themselves from dying by becoming dormant and drying to a tan

color. Once moisture returns, the grass greens up again.

Irrigation challenges. Sloped land and compacted soils present special challenges. On these areas, irrigation must be adjusted to reduce puddling and runoff. One solution is "cycle" watering. This method entails applying a portion of the water needed, just to the point before runoff. Irrigation is then switched to another area while water infiltrates the soil in the first area. Later the same day, the first area is watered a second or third time to reach the appropriate soil depth. To improve water infiltration on compacted soils, consider core aerating once or twice a year (see "Core Aeration," page 15-16) or amending the area.

Dry spots may indicate that it is time to water the entire lawn, or they can indicate a problem with either the watering system or the soil. Check sprinkler spray patterns to make sure they overlap. Watch to see whether water is being blown off track. Look for bent or tilted sprinkler heads and foliage that might be blocking the spray. If necessary, move sprinklers or prune plants. In some cases, an additional sprinkler head may be needed to provide sufficient moisture.

Also check the soil in the dry spot with a shovel or probe to look for compaction and construction debris. If the problem is construction debris, remove it and relevel the area for seeding or sodding.

Fertilizing

An adequate fertility program can produce dense, well-colored, manageable turf, while reducing weeds, moss, and some turf diseases. Underfertilized bluegrass or perennial ryegrass can exhibit poor color and turf thinning, which encourages weed invasion. However, fertilizer will not thicken up turf where compaction or other soil problems are present.

Conversely, overfertilizing increases the need for mowing and encourages thatch development. An overfertilized lawn also requires more water and pesticides, since fast-growing, succulent turf is more susceptible to diseases and insects.

Nitrogen (N) is the most important nutrient for promoting good turf color and growth, and N fertilizer usually is needed every year. Other nutrients may be needed, but determining which ones requires a soil test. Phosphorus (P) and

Calculating fertilizer application rates

Table 5 (page 15-15) gives fertilizer recommendations as pounds of nitrogen (N) per 1,000 square feet. Fertilizer package directions list rates to use as pounds of fertilizer per 1,000 square feet. Follow package directions, or use the steps below to calculate how many applications are needed and how much to apply each time.

1. **Convert nitrogen rate to fertilizer rate**. Divide the amount of N needed (table 5) by the percentage of N in the fertilizer, as indicated by the fertilizer analysis. For example, a 15-5-10 fertilizer contains 15 percent N. To apply 2 pounds of N using this fertilizer, you will need to apply 13 pounds of fertilizer (2 lb ÷ 0.15 = 13.3 lb). Leaving mowed clippings on the lawn may replace 20 to 30 percent of the required nitrogen (see "Mowing," page 15-10).
2. **Split the total**. Excessive fertilization at one time can burn turf and contaminate surface and groundwater. The amount of fertilizer that can be safely applied at one time depends on the product's N percentage; higher N content reduces the maximum application rate. Package labels indicate how much fertilizer can be applied at one application. Split the total required fertilizer from step 1 into two to four applications in order to avoid exceeding the maximum. For example, if 13 pounds are needed, and the maximum application rate is 3 pounds, split the total into four applications (13 lb ÷ 3 lb = 4.3). If the amount needed is less than the maximum application rate, all of the fertilizer can be applied at one time.

Sandy and gravelly soils have limited ability to hold water and plant nutrients, making them prone to nitrate leaching and root burn. To avoid these problems, cut the rate in half and fertilize more frequently, or use only organic or slow-release fertilizers.

See the sidebar "How Much Do You Need?," page 15-6, to calculate how much fertilizer to purchase.

potassium (K) are not always needed. A soil test every 3 to 5 years is very helpful.

Either organic or synthetic fertilizers can be used on turf. Organic fertilizers must be broken down into an inorganic form (cations and anions) by soil microbes before being utilized by plants. This breakdown, which releases nutrients slowly over the course of weeks or months, depends on the type of fertilizer, time of year, soil type, soil temperature, soil moisture, and microbial populations present in the soil. Thus, organic fertilizers can extend the supply of nutrients over time and reduce N loss to leaching. Using organic fertilizers takes advance planning to ensure that enough time is allowed for breakdown of materials so that nutrients are available when the grass needs them.

The most commonly deficient nutrient in lawns grown on alkaline soils is iron. Iron deficiency is treated using a chelated iron product or by altering soil pH prior to planting. A soil analysis can indicate whether a pH problem exists. See chapter 5 for more information.

Understanding ratios and analyses. The fertilizer analysis (the numbers on a fertilizer package) always reads in the order of N-P-K (nitrogen, phosphorus, potassium). The numbers indicate the percentage of each of the three nutrients in the package. For example, a 15-5-10 fertilizer contains 15 percent N, 5 percent P (expressed as P_2O_5), and 10 percent K (expressed as K_2O). See chapter 5 for more information.

On established turf, a fertilizer ratio of 3:1:2 or 3:1:1 is often recommended. A 3:1:2 ratio means the fertilizer contains three times as much N as P and twice as much K as P. An example of such a ratio is a fertilizer with an analysis of 15-5-10. A fertilizer analysis of 15-5-5 is an example of a 3:1:1 ratio.

Table 5. Recommended annual nitrogen application for cool-season turfgrass.

Species	Actual nitrogen (lb/1,000 sq ft/year)[a]
Fine fescue	1–2
Tall fescue	2–4
Kentucky bluegrass	2–6
Perennial ryegrass	2–6

[a]Within the recommended range, the need for nitrogen is determined by cultural practices such as irrigation and clipping removal. If irrigation is limited, less fertilizer is needed. Leaving clippings on the lawn also reduces the need for fertilizer.

How much fertilizer to apply. Grass species differ in the amount of N they require (see table 5). The sidebar "Calculating Fertilizer Application Rates," page 15-14 explains how to calculate the number of applications needed and how much to apply each time.

Timing fertilizer applications. The natural growth cycle of cool-season grasses influences the timing of fertilizer application (figure 3). Two applications are recommended during the fall, in early September and mid-November. Fall fertilization coincides with the normal, vegetative growth phase of cool-season grasses and promotes turf vigor. Benefits include the following: (1) increased storage of carbohydrate energy reserves, (2) stronger root systems, (3) increased shoot density, (4) greater stress tolerance, (5) better fall and winter color, and (6) earlier spring green-up. If a third or fourth application of fertilizer is needed, a late-April or early

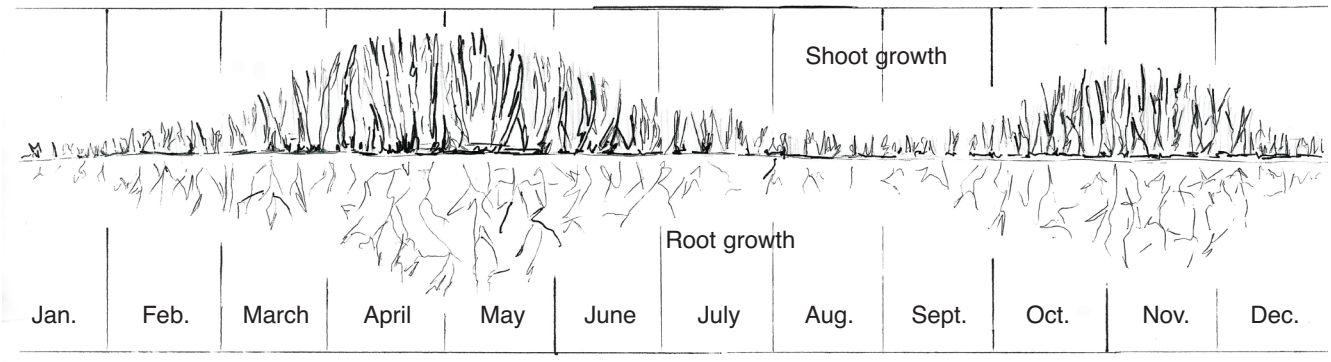


Figure 3. Cool-season grass growth cycle. Drawing by Aubrey Stribling, University of Idaho.

May application time will suffice to prepare the turf for summer heat stress.

Avoid fertilizing cool-season grasses in the heat of summer—July and August—as this is when they tend to go semidormant. Fertilizing at this time stimulates growth when the turf needs to slow down or "rest." Over time, summer fertilization will cause turf thinning, invasion by weeds, and higher susceptibility to diseases and insects.

How to fertilize. For even coverage, apply granular or pelleted fertilizer with a cyclone or drop spreader. Drop spreaders are more efficient and easier to use along driveways and walks, but remember to overlap the wheel areas to avoid leaving stripes. Set your spreader to apply the desired rate. Hand application is not recommended, except in small areas, because it leads to uneven coverage.

Core aeration

Coring (core aeration) involves removing finger-sized cores of turf and soil. It is accomplished using a core aeration machine with hollow tubes or tines (available from equipment rental centers).

Core aeration has several benefits. It increases oxygen and water infiltration in compacted soils, promotes fertilizer movement into the soil, and encourages root growth. Aeration can also reduce thatch development if done regularly. On tight, clayey soils or those exposed to heavy traffic, aeration might be needed once or twice a year.

Core aeration is usually done in spring or fall, when exposed roots are less likely to dry out. Make sure soil is well moistened before aerating, as tines cannot penetrate to the needed depth in dry soil. Travel in one direction first; then switch to a perpendicular direction. Cores are usually left to disintegrate in place. Irrigation helps wash the soil from the cores. As this soil mixes with thatch, it hastens thatch decomposition. Depending on soil type, core disintegration may take a few days to several weeks.

If cores are removed from the lawn, top-dressing may follow aeration. Top-dressing with ¼ to ½ inch of humus or a 50:50 mixture of humus and sand places looser material into the holes, thus improving future air and water infiltration. Use only construction sand, not river-washed sand.

Weed control

Discouraging weed growth. Limiting the germination and growth of weeds can reduce the need for herbicides. Because competition reduces seed germination and survival, one of the best weed deterrents is a dense stand of turf. Thick turf can choke out most weeds, while a thin lawn exposes the soil to weed invasion. Follow good irrigation and maintenance practices to promote a healthy lawn.

Raising the mower blade slightly can allow grass to shade out germinating annual broadleaf weeds. In order to reduce future weed populations, mow the tops off weeds before they form seed.

Controlling weeds. The first step to controlling weeds is to identify them. Weed life cycles and control measures vary. Annual weeds, for instance, are easier to control than perennial weeds, and small, immature weeds are more affected by herbicides than mature weeds.

Perennial weeds can be especially challenging. They are difficult to control without herbicides, due to their invasive and often extensive root systems. For instance, a single field bindweed plant can grow a 4-foot-deep × 20-foot-wide root system! Trying to dig out a perennial weed with a rhizomatous root system, such as bindweed, can be impossible, since cutting the rhizomes stimulates more shoot growth. Tough perennial weeds such as Canada thistle, field bindweed, and whitetop may require several herbicide treatments. Weekly hoeing to remove top growth reduces root vigor over time, but it can take years to eliminate established perennial weeds using this method.

Where possible, selective methods of control are recommended (e.g., hand pulling or herbicide application to individual weeds). Weed-and-feed formulations are not recommended for continued use near trees, shrubs, or other landscape ornamentals.

Make sure turf is well established and growing vigorously before herbicide treatment. To protect yourself, as well as your lawn and the environment, read and follow the herbicide label carefully. For more information on pesticides and pesticide safety, see chapter 9.

Herbicides will provide only temporary control if soil conditions and management factors that encour-

age weeds are not addressed. For example, soil compaction favors weeds and discourages turf growth. Common lawn weeds such as annual bluegrass, black medic, chickweed, clover, crabgrass, knotweed, prostrate spurge, and plantain thrive in compacted soils.

Timing weed control measures. Annual grasses such as crabgrass are usually treated with a preemergent herbicide in mid-March (or when the forsythias bloom). Preemergent herbicides kill seeds before they have a chance to germinate. Early April is a good time to treat summer annual weeds with a postemergent herbicide, while winter annuals are often treated in late summer or fall.

Fall is the best time to treat perennial weeds. It is difficult to kill established perennial plants in the spring; these plants move nutrients from the roots to aboveground parts in spring, so herbicides may not move down to the roots. In the fall, however, perennial plants translocate carbohydrates from their aerial portions to their roots, so a fall-applied herbicide will be carried to the root system, where it will work all winter to kill plant tissues.

For more information on weeds and their control, see chapter 14.

Turf renovation

Renovation is needed if a lawn becomes thin or too poor to save. Renovation is also useful for extremely weedy lawns or those with extreme thatch accumulation. On lawns with underlying problems, such as poor drainage or extreme compaction, renovation eliminates the frustration and cost of trying to keep sickly turf alive and provides an opportunity to correct the problem and start afresh.

To renovate turf, kill the grass with a nonselective herbicide and remove it with a sod cutter. Add soil amendments, if needed, and then plow or rototill. Grading, smoothing, and seeding or sodding (as described earlier in this chapter) are the final steps.

TURF PROBLEMS

Turf problems often go unrecognized until considerable damage has occurred. To effectively solve problems, you first must identify the cause. Some turf problems result from site shortcomings; others have their beginnings in improper maintenance practices.

Common problems

- **Improper watering** (too much or too little) is the single most important cause of poor turf. Follow irrigation recommendations.
- **Poor soil drainage** is seen on clayey or compacted soils. It may show up as standing water or as muddy or damp areas with sparse turf and moss. Cycled irrigation may help. If you choose to renovate the lawn, correct underlying problems at that time.
- **Summer dry spots** are common, especially in southern Idaho. Check for compaction, buried debris, and bent or blocked sprinkler heads. On steep slopes with recurring dry spots, consider terracing or replacing turf with a ground cover or meadow grass.
- **Mowing too low** (scalping) can stress turf and cause it to scorch and turn brown. Mow at the correct height for your grass species.
- **A dull, brown cast** on the surface of the grass blades could indicate a dull mower blade. If cut ends look shredded, it's time to sharpen the blade.
- **Yellowing turf** may indicate excess water, lack of N, or iron deficiency caused by high soil pH. Follow irrigation recommendations and obtain a soil test to check pH and soil nutrient levels.
- **Turf that grows too fast** between mowings usually indicates overfertilization. Follow fertilizer recommendations and fertilize during the proper times for cool-season grasses. Avoid fertilizing in July and August.
- **Thin turf** may result from shading or improper fertilizing and watering. Fertilizing cool-season grasses during the heat of summer can cause turf to thin over time. If shade is the culprit, reseed with a shade-tolerant mix or plant a ground cover.
- **Thatch buildup** is indicated by turf that feels spongy when walked on. Thatch should not be thicker than ½ inch. Dethatch if needed. Follow maintenance recommendations to minimize thatch buildup.
- **Crabgrass and other weeds**, when found persistently next to a driveway or sidewalk,

usually indicate that the turf is stressed by heat radiated from the paved area. An accepted xeriscape solution is to replace turf in these areas with a 2- to 3-foot-wide bed of shrubs and herbaceous perennials.

Insects

Insects can occur on even the best-kept lawns. Many lawn insects are not harmful. Where there is a history of insect pest problems, however, control may become necessary. Begin by identifying the insect. If needed, use an insecticide registered for the specific pest. Always read and follow pesticide labels.

Three common turf insects in Idaho are sod webworms, white grubs, and billbugs.

Sod webworms. This insect is the most common aboveground insect in Idaho lawns. Sod webworm larvae are ¼- to ¾-inch-long smooth caterpillars. They are green, gray, or light brown, with rows of regularly spaced darker spots.

Adults are white, tan, or brownish nocturnal moths that fly up from the turf when disturbed (as by mowing). They have a snout-like projection on the head and a very narrow body profile. (They fold their wings around their bodies instead of fanning them outward.) Eggs are laid in June and August, and larvae overwinter.

Sod webworm larvae feed at night on grass leaves and stems above the crown. Initially, damage appears as small, brown patches of grass that look scalped. As damage progresses, patches can merge into larger, irregular shapes. During the day, the caterpillars hide in silk-lined tunnels located in the soil near grass roots—hence the name "web" worm. Because sod webworms are surface feeders, they are easy to kill with insecticides.

White grubs. White grubs are larvae of several species of June beetles (June bugs) and chafers. The c-shaped, plump grubs are large (up to 1½ inches long and ½ inch wide), with six legs close to the head end. They are creamy white with brown heads.

Larvae feed on grass roots, and the resulting damage causes grass to succumb to drought stress. Grub-damaged grass dries out and is easily pulled out or rolled back like a carpet. A deep thatch layer can protect grubs. Digging by birds, skunks, and raccoons often indicates that grubs are present. If white grub damage is suspected, check for grubs in the top 2 to 3 inches of soil. Adult beetles do not feed on grass.

One application of insecticide often gives season-long control.

Billbugs. Adult billbugs are slow-moving, black weevils (¼ to ½ inch long) with a long, curved snout—hence the name "bill" bug. The c-shaped larvae are tiny (⅛ to ¼ inch long) and creamy white with brown heads. They look similar to white grubs, but are much smaller and lack legs.

Adults feed on grass blades and stems, while larvae feed on roots. Billbug damage often occurs in turf that is stressed by heat and drought (e.g., turf that abuts cement or is growing on a slope). Damage appears as spotty patches of yellow or dead grass. Damaged grass breaks away at the crown as you pull on it or can be rolled back like a carpet. A sawdust-like material (frass) may be evident.

Begin checking for adult weevils in late April to mid-May. Adults are slow moving and nocturnal, so check at night with a flashlight. They often can be found crawling on pavement near lawns. Digging may reveal billbug larvae; after mid-July, larvae move deep into the soil and are harder to detect.

The key to billbug control is to kill the adults before egg laying begins in May by using an appropriate insecticide.

Diseases

Turf disease problems are uncommon in Idaho's arid and semiarid climates. Fairy ring fungus is one frequently seen disease. At high elevations or where snow accumulates for long periods, snow mold may be a problem. See table 6 (page 15-19) for a list of lawn diseases, descriptions, and solutions.

For long-term disease control, you may need to adjust cultural practices to discourage pathogens. Sometimes, a single change (such as irrigating less frequently, reducing fertilizer rates, or mowing at the correct height) is sufficient to keep turf disease-free.

In recent years, major advances have been made in the development of effective fungicides and bactericides for turfgrass disease control. When necessary, carefully select and use these products, and always read and follow the pesticide label.

Table 6. Lawn diseases.

Disease/Symptom	Conditions favoring development	Management
Brown patch (*Rhizoctonia solani*) Brown, irregularly shaped or circular patches	Moist, warm (above 80°F)	Avoid excessive, frequent irrigation and high N fertility.
Fairy ring (*Marasmius oreades*) Rings of dark green grass or arches of dead grass, with or without small, tan mushrooms (Mushrooms appear mostly in spring and fall.)	Mild, moist. Fungus grows on decomposing organic matter in the soil.	Core aerate or, for small areas, use a potato fork to poke holes in rings. Soak rings with water daily for 1 month to reduce hydrophobic patches. Keep turf well fertilized.
Fusarium patch (*Microdochium nivale*) Browning and thinning of turf in large, irregular spots (1 to 8 inches)	Cool, wet. Worse in spring and fall.	Promote soil aeration and drainage by amending the soil and following irrigation recommendations. Avoid excessive N.
Helminthosporium diseases (*Helminthosporium bipolaris, H. Drechslera,* and *H. Exserohilum*) Root and crown rot; yellowing and thinning of turf; tan to purple spots on leaves	Moist. Common on bluegrass and perennial ryegrass.	Water in morning. Pick up clippings. Do not let grass get matted. Avoid excess N.
Necrotic ring spot (*Leptosphaeria korrae*) Dead circles, arches, and eventually patches; starts small but can spread to cover large areas	Found on seeded and sodded bluegrass. Most common on 2- to 5-year-old sodded bluegrass.	Choose a resistant cultivar. Promote deep-rooted turf with proper fertilization, irrigation, and mowing.
Rust (*Puccinia* spp.) Leaves turn yellow; yellow, orange, or reddish-brown powdery growth on leaves	Variable. Most common on certain cultivars of bluegrass and perennial ryegrass.	Increase N. Water during dry periods. Mow frequently.
Snow mold, gray (*Typhula* spp.) Irregular dead, bleached areas (2 to 24 inches) with gray mold, usually under or near melting snow	Cold, wet. Worse under prolonged snow cover.	Avoid heavy late N fertilization.
Snow mold, pink (*Microdochium nivale, Fusarium nivale*) Circular, light-brown patches (2 to 12 inches); grass blades are faded and covered with pink fungus	Cold, wet. Worse under prolonged snow cover.	Avoid heavy late N fertilization.
Yellow patch (*Rhizoctonia cerealis*) Light brown to yellow patches or rings	Prolonged moisture at 40 to 60°F	Ensure deep rooting. Avoid excessive irrigation and fertilization.

Adapted from *Sustainable Gardening: The Oregon-Washington Master Gardener Handbook*, Oregon State University Extension publication EM 8742.

FURTHER READING AND RESOURCES

Books

Christians, N., A. Ritchie, and D. Mellor. 2007. *Lawns: Your Guide to a Beautiful Yard*. Merideth Corp., Des Moines, IA.

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Websites

University of Idaho
http://www.extension.uidaho.edu

Colorado State University
http://csuturf.colostate.edu

Oregon State University
http://horticulture.oregonstate.edu/group/beaverturf

Utah State University
http://extension.usu.edu/yardandgarden/htm/lawns

Washington State University
http://turf.wsu.edu

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Chapter 16
Landscaping

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I. Introduction

Horticulture is an art and a science—especially when it comes to landscaping. Imagine the landscape as the canvas with the greenscape (plants) and hardscape (sidewalks, edging, and patios) providing the colors, shapes, and patterns of the living portrait. Landscape architects even use the term "plant palette" when referring to plant lists.

The skill to match the proper plant to the proper environment and to provide the proper cultural inputs to guarantee the survival of plants on the landscape is the science of landscaping. In addition to being more attractive and easier to maintain, the benefits of a well-planned, well-designed landscape include economic savings (reduced inputs of water, fertilizer, and pesticides), enhanced real estate values, and personal satisfaction and peace of mind.

To help you create an attractive and functional landscape, we will discuss some basic principles of landscaping including planning and design, plant selection, and installation and maintenance. Although the following principles are primarily for homeowners, you also can apply them to larger properties or landscapes.

II. Definitions

A. Landscape—An arrangement of outdoor space for a specific purpose or goal. Goals may be as general as increasing the attractiveness of a landscape to more specific things such as reducing the amount of water, maintenance, and chemical inputs into the landscape.

B. Landscape Design—A blueprint or drawing of the landscape that the designer creates to fulfill the property owner's goals and objectives for the landscape.

C. Landscape Architect—A professional who creates landscape designs.

D. Landscape Plan—Describes how you are going to meet the goals and expectations of the landscape design.

E. Landscape Maintenance—The specific activities (weeding, spraying, watering, fertilizing, etc.) needed to meet the goals and objectives of the landscape plan.

F. Landscape Management—Coordinating the maintenance procedures to meet the landscape plan's objectives .

G. Landscape Contractor—Someone who installs and sometimes maintains landscapes. This individual also may be the landscape manager who is responsible for meeting the landscape plan's objectives.

H. Landscaping—Includes all of the concepts from design to maintenance.

III. Creating a Plan

Have a plan before you plant! Whether you are developing a landscape plan for a new home or renovating an older landscape, it is important to have a plan before you do anything. In the long run, not having a plan may create maintenance problems and reduce the overall appearance of the landscape. The following steps will help you develop a plan for a landscape that is both functional and aesthetically pleasing.

A. Define Your Goals and Objectives

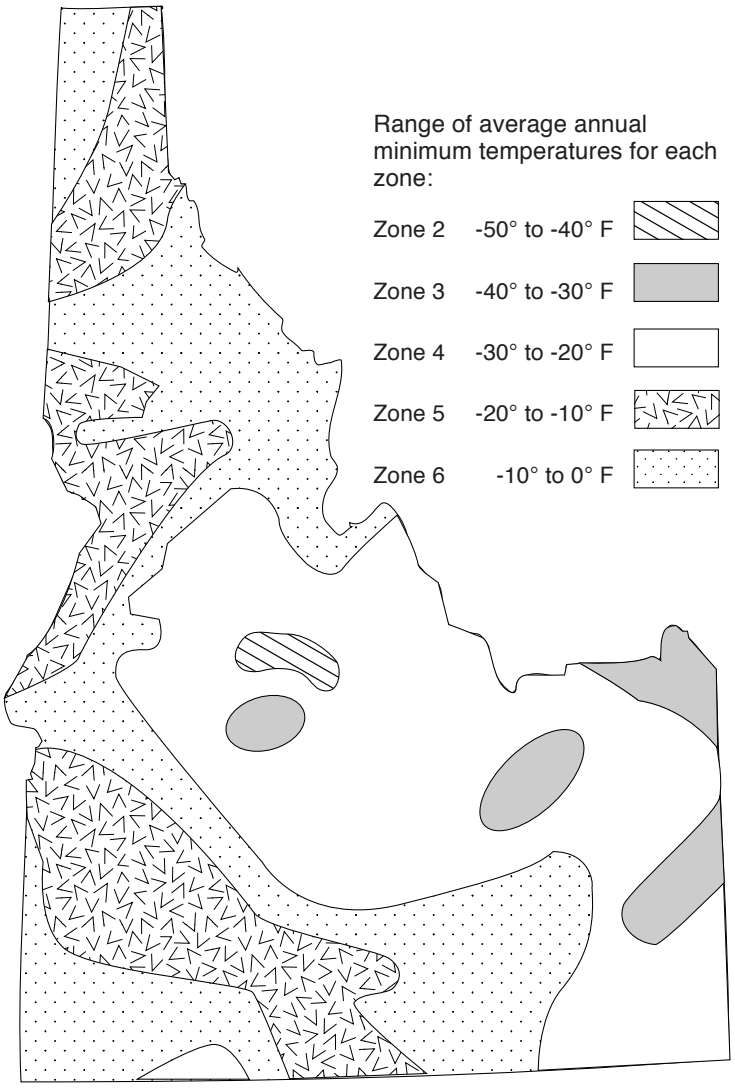
This is the most important step of the landscape process. Establishing clear goals and objectives at the beginning will help you achieve the benefits you hope to receive from your landscape plan.

Decide what type of plan best fits the needs of your household, while working within the

economic, social, environmental, and physical constraints that will affect your final landscape plan. Specific goals and constraints might include the following:

1. Goals
   a. Low maintenance, low input (includes reduced watering, pesticide and fertilizer applications, and less mowing).
   b. More privacy.
   c. More recreation area.
   d. More color.
   e. More wildlife habitat (includes forage and cover for birds and desirable insects).
2. Constraints
   a. Environmental conditions (includes climate, soil, and precipitation).
   b. Physical barriers or obstacles on the landscape.
   c. Social (includes public ordinances restricting water use or plant selection).
   d. Economic.
   e. Physical handicaps.

Fig. 1. USDA plant hardiness zones for Idaho.



B. Do a Thorough Site Analysis

Gather as much information as possible about your site and the area where you live. Make a preliminary map of your property, drawn to scale, that includes the locations of your house, buildings, sidewalks, and driveway. Indicate on the map, or on a separate sheet of paper, the following information:

1. Macroclimate—This refers to major weather patterns (temperature and precipitation) that affect large areas. In Idaho, cold hardiness is a critical factor for determining plant survival. Idaho covers five USDA hardiness zones, 2 to 6, (-50° to -10°F), with temperatures being affected by elevation and latitude (Fig. 1).

   Temperature and precipitation can vary considerably within a hardiness zone. Always consult local or regional weather services or extension publications for specific weather information for your area.
2. Microclimates—These are the weather patterns that the landscape in your immediate area affects. When conducting a site analysis, look for potential problem areas such as hot spots, frost pockets, wet spots, or shaded areas. Mark these microclimates on your preliminary map for future reference.
3. Soils—See Chapter 4 for more information about soils. In regard to urban or residential landscapes, consider the following:
   a. Most urban or residential soils are disturbed soils and probably won't resemble the less disturbed, native soils of the surrounding region.
   b. Proper soil conditions are as important to plant growth and survival as ideal climate conditions. Drainage, pH, structure, organic matter, and mineral composition are factors to consider in relation to plant growth.

c. Because you are working with a small area, it is easier to improve the soil using various soil amendments.

Note: If your site has a lot of variability in the soil, you should indicate the different areas on your preliminary map and plan accordingly. See the UI Extension Bulletin 704, "Soil Sampling," for information about taking soil samples on your site.

4. Topography—Besides altering the microclimate, topography can affect drainage and make some areas difficult to plant and maintain.
5. Aspect—Note the exposure of the site relative to the sun. This is more critical in mountainous areas or areas with steep hills. Generally, plants growing on the warmer, south-facing side of a slope will break dormancy faster than plants growing on the north-facing side. This provides a longer growing season, but it also can make plants more susceptible to late frosts and other freezing-related injuries.
6. Existing plant materials and structures—Show existing plant materials, sidewalks, driveways, patios, and other structures on your preliminary plan.
7. Access—Besides driveways and sidewalks, plot "traffic" areas around the landscape. Consider ways to improve access to your home or other parts of the landscape.
8. Easements—Draw these on your map to prevent planting any permanent plant materials in these areas.
9. Overhead utility lines, sewer lines, underground cables, and transformers—Note these on your preliminary site plan and plan accordingly. Some basic rules for planting in these areas include:
   a. Plant trees and shrubs away from utilities;
   b. Plant taller or broad spreading trees away from overhead lines, and use shorter, slower growing trees for closer planting if you must plant near overhead utilities;
   c. Don't plant species near utilities that can prevent access or cause maintenance problems; and
   d. Avoid planting species such as poplars, willows, and cottonwood with dense, fibrous roots near sewer lines or septic systems.

Note: See the UI Extension CIS 991, "Landscaping and Utilities: Problems, Prevention, and Plant Selection," for more information.

10. Views—Indicate your views looking out from your house, and approaching your house. What do you want to see? What don't you want to see? What do you want others to see or not see?
11. Available water—Show the location of your water sources. If your property has areas that are difficult to water, you may want to modify your plan to meet the needs of these areas by using drought-tolerant plants or hardscape (nonliving) materials.
12. Local ordinances—Consult state and local authorities for specific regulations about planting trees and shrubs along streets, sidewalks, and rights of way.

C. Define Use Areas

You can divide use areas into three major categories:

1. Public areas—This usually describes the front of your landscape. The primary function of this area is aesthetics and to "welcome" visitors to your home.

Note: There are no distinct boundaries on these areas, and they will frequently overlap in terms of function and appearance. Within these major use areas, you should designate specific use areas (e.g., recreation, perennial flower beds, vegetable garden, and patio) for the various activities that you are planning for your landscape. For more information about planning your landscape see CIS 990, "Water Conservation in the Landscape."

2. Private areas—These are the areas used for recreation, family activities, and entertaining.
3. Service areas—These areas are reserved for the vegetable garden, composting, pet and livestock areas, storage shed, woodpiles, and other utilitarian purposes. They can include areas that are difficult to maintain, have limited access to water, or have poor soil.

D. Define Planting Areas

Plot planting zones based on water needs or the plants' maintenance requirements and to meet the landscape plan's objectives.

1. Hydrozone or group plants with similar water needs in the same areas. For example, consider planting willows, dogwoods, or birches that usually thrive under moister conditions near annual flower beds (high water users). To conserve water, do not mix plants that have low water requirements with plants that have high water requirements.
2. Reduce maintenance activities by grouping plants with similar maintenance requirements together.
   a. Perennials generally require less frequent maintenance than annuals. In Idaho, most of the maintenance of perennials occurs in the spring and fall.
   b. Plant trees or shrubs with messy leaves, fruits, or seeds away from flower beds especially if these plants reproduce easily from seed. It is easier to rake this material up or remove the new seedlings from a lawn than from your planting beds.
   c. Group shrubs with similar flowering periods together so it's easier to remember which plants you need to prune in early summer and which ones in the fall or early spring. Grouping also will help you focus maintenance activities on specific areas of your landscape.
3. Design planting areas to meet the objectives of your landscape plan. If your objective is privacy, design planting areas to maximize privacy. On the other hand, if you are concerned about security, you may want to leave large areas of open space with reduced opportunities for concealment. Perhaps you would like to encourage more wildlife on your landscape? Then you will need to plan for more areas that provide both food and shelter. Plan and plot your objectives before starting to plant.

E. Principles of Design

The house is the focal point of the design. The landscape should complement, not clash, with the house. The landscape is an extension of the living space. Just like the appearance and arrangement of your house affects your personal living space, so does the appearance and arrangement of your landscape. It affects you aesthetically based upon your inward and outward views and from a functional perspective.

1. Balance—You can achieve balance on the landscape in two ways:
   a. Symmetrically: Place equal numbers of plants, plants of equal size, or structures or planting beds of equal size opposite each other on the landscape. For example, plant two shrubs of the same size and species on opposite sides of an entryway or plant two flower beds of equal size, dimension, and species composition on opposite sides of a sidewalk.
   b. Asymmetrically: Balance plants and structures in terms of volume of space occupied on the landscape. One example might be to plant a large red oak on one side of the yard to counterbalance a mass planting of ornamental shrubs on the opposite side. Also, you could counterbalance a deck with a perennial bed.
2. Movement—You can create a sense of vertical and horizontal movement on the landscape. For example:
   a. Tall, columnar trees or shrubs draw your eyes upward, whereas a low, flat bed of colorful annuals pulls your eyes downward.
   b. Lines, especially curved lines of walkways or planting beds, create a sense of motion that encourages you to move

visually and physically through the landscape.

3. Harmony—The proper use of space, color, texture, and plant materials on the landscape creates harmony.
   a. Use plants and structures that are in scale with the house.
   b. Enhance the overall landscape design with plants and plantings that complement each other.

F. Elements of Design

1. Space—Use space effectively by considering the following principles:
   a. Select a mixture of plants that provide an effective transition from the vertical plane (air) to the horizontal plane (earth) to create a better sense of harmony and balance.
   b. Plant trees that provide filtered shade (e.g., honey locusts) rather than trees that provide heavy shade (e.g., maples) for a more subtle influence on vertical space.
   c. Select different species of plants based upon their form and structure as well as their color or flowering habits.
   d. Use curved lines to create a more natural, informal appearance. Straight lines are less natural and more formal.
2. Color—Color affects the landscape design in various ways.
   a. It gives the landscape movement, accent, shade, and depth. For example, bright colors such as reds and yellows are good for accent, variety, and for attracting attention to specific areas. Use blues and dark colors to create shade and depth.
   b. Color affects moods. Reds are exciting colors that generate energy; pinks and greens are soothing colors; and light blues create a cool feeling.

Note: A color wheel will help you make effective color choices. They are available at crafts, art, paint, or office supplies stores.

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3. Texture—Texture is the "visual feel" of the landscape or of landscape plants. Some plants have a coarse texture because of their foliage, branching patterns, or bark. For example, a horse chestnut tree with its large, serrated, compound leaves will have a coarser texture than a weeping willow.
4. Plant arrangement—The individual attributes of the plantings and overall effectiveness of the landscape plan is affected by plant arrangement.
   a. Specimen plants draw attention to themselves because of their color, shape, or size. Plant them by themselves or enhance beds with mass plantings. Large shade trees (oaks, maples, and conifers) or small trees and shrubs (ornamental crabapples, hawthorns, burning bushes, and viburnums) make effective specimen plants.
   b. Mass plantings enhance the appearance of plants that may not be as attractive or effective individually. Annuals, perennials, small shrubs, and ground covers are generally more effective as mass plantings. Also, on more naturalized landscapes, it is best to plant shrubs in odd numbered clusters for a more natural appearance.

G. Plant Selection

Select plants that meet your design objectives. These might include the following:

1. Functional.
2. Aesthetically pleasing.
3. Cold hardy—Check if the plant is adapted to the minimum temperature zone for your area.
4. Low maintenance—Select species that require a minimum amount of pruning, watering, and raking. Cut the frequency of maintenance time for woody plants by reducing the variety of early- and late-flowering species.
5. Low input—Select plants that require less water and chemical inputs.
6. Nonpoisonous and safe—This is especially important in areas that children will use. Try to reduce the number of plants

that may have poisonous fruits, flowers, or foliage or that have thorns or spines that can cause injuries.

Note: Contact your local Extension educator or the Poison Control Center if you have any questions.

7. Appropriate selections for planting near utilities.
8. Economical—What we want is not always what we can afford. Your budget will determine your choice and size of plant materials that you can purchase.
9. Native or nonnative species—Some people recommend planting native (indigenous) species over nonnative (nonindigenous) species because, theoretically, they are better adapted to an area. This is not necessarily true since most residential landscapes are disturbed sites and unnatural environments that probably will have more inputs (irrigation, fertilizing, and pest control) than the preexisting natural environment. Native plants are not always more drought tolerant than nonnative species either.

Note: The bottom line is to choose the best plant that is adapted to the area you are going to plant it in and that meets your desires for your landscape.

10. Nonnoxious—Noxious weeds are a serious problem in agricultural areas. If you plan to purchase or introduce plants from out of state, contact your local Extension educator for information or the County Weed Control supervisor about noxious weeds in Idaho.

H. Other Considerations When Buying Plants

Some other important things to consider when you are **buying** plants are:

1. To ensure greater adaptability to your area, purchase plants that local seed sources have produced. This is especially important for woody and herbaceous perennials.
2. Before purchasing plants via mail order, check local nurseries. You may save money, and you will be able to inspect the plants for pests and diseases. Also, you are more certain of getting a live plant.

IV. Installation and Renovation

Follow these steps when installing a new landscape or renovating an older one. The sequence depends upon your needs and abilities.

A. Primary Hardscape

Install sidewalks, driveways, walls, terraces, decks, patios, and ponds. These will define your use areas and will prevent future damage to your landscape if done in the beginning.

B. Install Planting Beds

Amend soils, if necessary, and install weed barriers, if desired.

C. Plant or Move Trees and Shrubs

Plant and transplant shrubs early in the spring or late fall when plants are dormant and the soil is workable. Do not transplant large trees and shrubs when they are actively growing.

D. Install Automatic Irrigation System

E. Plant Lawn or Ground Covers

Add soil amendments if you have poor soils—especially soils low in organic matter—or plant some type of an annual cover crop to improve the soil before planting.

V. Maintenance and Irrigation

A. Maintenance

Review the maintenance requirements of your landscape plan before actually installing the landscape. This will save you a lot of frustration and expense in the long run. Refer to other Master Gardener chapters for more information about the following maintenance activities:

1. Proper pruning—Timing and technique is important. (See UI BUL 819, "How to Prune Deciduous Landscape Trees.")
2. Staking and wrapping trees or shrubs.
3. Mulching—Includes organic, inert, and synthetic mulches. Organic mulches should not be deeper than 2 to 4 inches. Incorporate fine mulches such as sawdust into the soil. Plastic, nonporous mulches are not recommended for landscape use.

(See UI Extension CIS 858, "Using Bark and Sawdust for Mulches, Soil Amendments, and Potting Mixes," for more information about mulches on the landscape.)

4. Pest control—Includes disease, insect, and weed control.
5. Proper turf management—Mow grass to proper heights. Leave trimmings as a mulch to improve soil and water retention, fertilizing, and top-dressing. Proper watering is also important to maintain a healthy lawn, and to avoid waste, runoff, and water pollution. (See Chapter 14 for more information and publications about establishing and maintaining a lawn.)

B. Water Management

Match the irrigation program to the plants' moisture requirements, the time of the year, and soil types. Important components of a good water management program include:

1. Proper timing and duration of watering—Deep and infrequent waterings are better than shallow frequent waterings. Deep water evergreen trees and shrubs before the ground freezes in the winter.
2. Match sprinklers and irrigation scheduling to plants and planting areas—Trees and shrubs require less frequent watering than turf and herbaceous ornamentals.
3. Monitor and maintain the irrigation system frequently to prevent runoff, waste, and pollution.

Further Reading

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CIS 1068 Fertilizing Landscape Trees

PNW 496 Grafting and Budding Plants to Propagate, Topwork, Repair

BUL 819 How to Prune Deciduous Landscape Trees

BUL 644 How to Prune Coniferous Evergreen Trees

CIS 991 Landscaping and Utilities: Problems, Prevention, and Plant Selection

CIS 1054 Low Input Landscaping

PNW 500 Plant Materials for Landscaping—A List of Plants for the Pacific Northwest

EXT 704 Soil Sampling

CIS 858 Using Bark and Sawdust for Mulches, Soil Amendments, and Potting Mixes

CIS 990 Water Conservation in the Landscape

Published 1994.

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Chapter 17
Landscape Plants

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I. Why Ornamental Plants?

Landscape plants are placed as they are for various purposes: to create shade, to define space, to enhance architecture, to provide food (e.g., fruit trees), and to further general aesthetics. These plants should be installed according to a plan, so that they are correctly selected and placed to create the desired design effect. Plantings should be in tune with the environmental situation and take into account such things as exposure, amount of light, pH, water availability, and soil type.

Trees and shrubs will last in the landscape for many years. However, when a stress is imposed on a plant, that plant becomes much more susceptible to other problems, including insects and disease. A large percentage of landscape plant problems can be related directly to improper selection of plant material and improper cultural practices that lead to plant stress. In some cases, the effects of improper cultural practices may not be seen for years.

II. Soils and Water Considerations

A. Soil Composition

Soils are roughly 50 percent solid material and 50 percent pore space. (Pores are holes in the soil that are either filled with air or water.)

1. Pore space, ideally, should be 50 percent air and 50 percent water.
   a. Air is necessary for root respiration and normal metabolism, including the uptake of water.
   b. Water is used in transpiration within the plant and for the transport of dissolved mineral nutrients from the soil to roots and on up the plant through the xylem.
2. The solid material is composed of organic matter, decomposed rock, and various biological life.

B. Water Status Definitions

1. Hygroscopic water—Tightly bound to the soil particles; not available for plant growth.
2. Capillary or available water—Held less tightly to soil particles; available for plant usage.
3. Gravitational water—Moves with the force of gravity; drains away. This water is not available to the plant.
4. Saturated conditions—Tend to exclude air; detrimental to most plants (with the exception of aquatic species).

C. Water Movement

1. The thicker the film of water, the greater the ease of movement in the soil. The thinner the film of water, the harder it is to move through the soil, therefore, becoming less readily available to plants.
2. Water movement is always from wetter areas in the soil mass to drier areas.
   a. When water is lost from the soil surface (through evaporation), more water is drawn up from lower levels.
   b. When a plant draws water in through the roots, more water moves into the area.
   c. Roots **do not** seek water; roots grow where water is.

D. Soil Structure (Aggregate Size)

1. Soil particles may be made up of many small particles clumped together.
   a. Spaces (macropores) between large particles contain air for root respiration.

b. Spaces between smaller particles and within very large particles contain capillary (available) water. Water also is found on the surface of larger particles.

2. Increase aggregate size by:
   a. Adding of calcium (usually gypsum): Only works with clay soils.
   b. Adding organic matter: Water and air are found **in** and **between** the organic matter particles. Organic matter loosens a clay soil for better air and water movement. In sandy soils, organic matter helps hold water and nutrients.

E. Drainage Problems
1. Hard, compacted soil—Air space squeezed out; low infiltration, little air space, and slow drainage.
2. Impenetrable layers—Clay layers, hardpan, and plowpans, etc.; may not allow water or roots through.
3. Fine-textured soil—Preferable over a coarse-textured soil or gravel.
   a. At the interface, water cannot move rapidly into coarse soil; consequently, moisture is limited or not continuous.

Note: The interface is where one soil type stops and another begins.

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   b. Water movement downward is impeded across the interface, and much of the finer soil's pore space may fill with water.
4. Coarse-textured soils over or contained within a fine-textured soil.
   a. Drainage through coarse soils is rapid.
   b. Infiltration into fine soils is slow, causing macropores in the coarse soil to fill with water.
   c. Roots lack oxygen and root rots may ensue.
   d. Add organic matter to the coarse soil to slow water penetration.

F. Overcoming Drainage Problems
1. Till by adding 3 to 4 inches of organic matter.
2. Raise plant slightly above grade and create a bed with good soil, or a raised bed.
3. Add tile to create good drainage.
4. Contour slope away from plants so that water runs off.
5. Break through hardpan layers.

III. Planting and Site Preparation

A. Types of Plant Materials
1. Bareroot (B.R.)—Dug without a ball of soil; little or no soil around the roots. Examples: dormant deciduous shrubs, roses, deciduous trees, and small evergreens.
2. Balled and burlapped (B and B)—Dug with soil that is enclosed in burlap or some sort of synthetic material. The root system has been cut for easier handling and transport.
3. Field-potted—Dug with or without soil and potted into a container.
4. Container—Plant grown for a time in a container.

B. Planting
1. Bareroot
   a. Cut back damaged or broken roots.
   b. Dig hole twice as large as the root system.
   c. Put the plant in the hole at the same level it grew originally. Build a cone or mound of soil at the bottom of the hole under the plant for support and to aid in spreading the roots. Be sure the roots are spread.
   d. Backfill with native, **not amended**, soil.
   e. Water thoroughly.
   f. Fertilize with a high phosphate fertilizer (5-10-10) or a balanced slow-release fertilizer (10-10-10). Fertilizers may be added to a backfill material. Fertilizer may also be added to the soil surface after watering. Always follow label directions as to amount.
2. Balled and burlapped.
   a. Dig hole twice as wide as the ball of soil.
   b. Remove **all** of the rope, twine, or string on the ball after setting it in position in the hole. The burlap can be sliced on the sides, and the top burlap

should be laid back so that no burlap is exposed above ground. Burlap exposed above ground will wick moisture away from the root ball. Synthetic or plastic burlaps should be removed totally. Unless B and B trees have been kept in burlap for a long time, don't worry about girdling roots or cutting damaged roots.

c. Follow steps d through f of Section B, subsection 1.

3. Container plant.
   a. Dig hole twice as wide for root system spread.
   b. **Remove** container, no matter what type.
   c. Roots.
      - If the roots are not circling (potbound), carefully spread the exterior roots outward, away from the soil ball.
      - If the roots are circling, make three to four vertical cuts into the sides of the root ball (1/4 to 1/2 inch into the ball). If the roots are woody and cannot be cut with a knife, lay the ball on its side. Using a sharpened spade or shovel slice through the lower half of the root ball. This is called "butterflying." Spread out the two flaps of roots and place in planting hole so the top of the root system is level with, or slightly higher, than the surrounding soil. When butterflying, be sure not to damage the crown by splitting too close to the trunk. Make sure the split area is filled with soil so that no air spaces are left.
   d. Follow steps d through f of Section B, subsection 1.

C. Pruning After Planting
   1. Leave as much of the crown intact as possible, and remove only dead, injured, and diseased branches.
   2. Remove interfering, rubbing, or poorly placed branches.
   3. Remove a branch from narrow "V" crotches or multiple leaders.
   4. Prune to shape, if necessary.

D. Staking
   1. Avoid staking unless wind is a problem. Stake as low on the stem as possible and remove the stake after 1 year.
   2. Reasons for staking.
      a. To anchor plant until it can root into the soil.
      b. To protect the tree from slanting with the wind.
      c. To straighten a crooked trunk.
   3. Used mostly for B.R. and B and B plants.
   4. One- and two-stake methods.

IV. Plant Problems

Problems associated with plant roots may show up in other plant parts, especially the leaves.

A. Circling Roots/Potbound
   1. Symptoms—A general decline of plant vigor over a period of time.
   2. Causes—Plant remaining in container too long at some stage of development, not necessarily the last stage of production.
   3. Remedies—"Butterfly" the root ball, or cut and spread the roots before planting.

B. Girdling Roots
   1. Symptoms—Girdling roots limit water and nutrient transport causing deterioration of the plant. Top growth diminishes; plant is stressed.
   2. Causes—An impenetrable planting hole; twisting the plant after setting into hole; bending roots to fit into a hole that is too small; and planting potbound or rootbound container stock.
   3. Remedies—Chop off girdling root; spread roots when planting; remove debris or rocks in planting area.

C. Kinked Roots/One-Sided Root System
   1. Symptoms—A general decline of plant vigor over a period of time.
   2. Causes—Improper production methods (such as dragging with a mechanical planter causing "J" hooked roots or jamming the plant in the pot or the planting hole).

3. Remedies—Cut off kinked roots when planting; carefully spread and straighten the roots.

D. Root Rots

1. Symptoms—Soft, brown, partially to totally decayed roots resulting in wilting or death of the plant.
2. Causes—Cause varies with susceptibility of the plant. There might not have been enough soil aeration; the water table might be high; the backfill might have been amended with fresh manures when planting; or the soil might be waterlogged.
3. Remedies—Improve downward and lateral drainage; tile, if necessary; and plant in raised beds. Select a water-loving species of plant and amend the soil to improve drainage.

E. Changing Soil Grades

1. Symptoms—No buttressing or flaring roots at tree base; general decline of tree; leaves and branches die from top down; collar rots are evident. The decline may take several years to occur or to complete. Susceptibility varies with species.
2. Causes—Filling with soil or pavement on top of an established root system results in a decreased air supply to the plant changing drainage and water patterns.
3. Remedies—Cover roots with a thick layer of gravel, then with soil. Provide drainage, and in some cases, welling the trunk will help.

Note: Welling is the building of a "well" or wall around the tree several feet out to keep soil away from the trunk.

F. Trenching/Cutting Roots

1. Symptoms—Cutting roots reduces water and nutrient uptake. The decline may take several years to occur or complete. Cuts can become infected with root rot leading to the decline of plant growth. The result is often the death of a tree from the top downward. Sometimes the decline is limited to that half of the tree with the cut or damaged roots.
2. Causes—Removing top layers of soil to change a grade or damaging roots by cutting.
3. Remedies—Avoid cutting large roots; fertilize and water the rest of the root system; use a high phosphorus fertilizer to encourage new root development.

G. Compaction

1. Symptoms—Decline of the tree from the top down.
2. Cause—Soil compaction after the plant is in the ground.
3. Remedies—Direct foot traffic and machinery away from the dripline of trees. Aerate soil using a core aerator or cushion the soil with a thick mulch.

V. Stem Problems

Stem maladies usually arise from improper cultural practices and stresses to the plant.

A. Heart Rot

1. Symptoms—Decay of heartwood.
2. Causes—Improper pruning, topping, breakage, or wounding of the stem or the large branches.
3. Remedies—Prune properly and avoid wounding. Remove decayed branch wood; if rot is in an advanced stage, remove the tree.

B. Stem Wounds

1. Symptoms—Cankers, girdling, holes, splits, and oozing.
2. Causes—Various, including hitting the tree with lawn mowers and string weeders; leaving support wires or B and B string around stem; diseases, borers, and sunscald.
3. Remedies—Stay away from plant stems and trunks with equipment. Remove all lawn grass to at least 1 foot from the trunk. Keep all mulch 2 to 3 inches from plant stems. Identify and treat insects or disease. Remove labels and ties when planting. Painting or spraying with tree wound compound does **not** improve healing, but it may prevent insect entry.

C. Sunscald or Southwest Disease

1. Symptoms—Bark tends to be blistered, burnt, dead, or split on the southern or

southwestern sides of the trunk. Young and newly transplanted trees are the most susceptible.

2. Causes—Alternating freezing and thawing of bark on sunny side of tree during winter. Intense heat during summer.
3. Remedies—Shade south and southwest sides of trunk; wrap the trunk with tree wrap or paint with white, water-based (latex) paint. If there is an advanced stage of damage, carefully remove any dead bark, apply tree wound dressing, and wrap to keep insects out of heartwood.

D. Branch Rots and Infections

1. Symptoms—Oozing, cankers, holes, and splits.
2. Causes—Improper pruning. Branch stubs or flush cuts leave a tree open to disease and insects.
3. Remedies—Prune correctly; cut back only to the branch collar; do not top trees. Treat insects and diseases when first noticed.

E. Damage to Crotch Areas

1. Symptoms—Splits, oozing at crotch.
2. Causes—Narrow "V" crotches, borers, water gathering in crotch.
3. Remedies—Prune out all but one of the leaders if the tree is young and has multiple leaders. Narrow branch angles can be spread when the tree is young; cable or brace narrow crotches if the tree is older to prevent breakage.

F. Freeze Damage

1. Symptoms—Blackened tissue; dead twigs or buds; death of plant. Stem dieback. Usually younger stems die, but older wood also can be damaged during severe winters. There is generally a partial to total necrosis of the young leaves. Older leaves may become distorted later. New growth might have been frozen by late spring frost when plant was in the soft-growth stage.
2. Causes—Lethal winter temperatures and early or late frosts.
3. Remedies—Use frost prevention methods; select trees and shrubs specified for your zone; do not fertilize trees and shrubs after July 1.

G. Graft Incompatibility

1. Symptoms—Large overgrowths above and below union; earlier than normal fall coloration; a stem that breaks off at graft.
2. Cause—Incompatibility between scion and stock.
3. Remedy—Purchase plants rooted from cuttings or use a reliable source of grafted stock.

VI. Leaf Problems

Problems with stems and roots often will show up in the leaves. If a plant is wilted, the leaves are either not getting enough water or are losing water faster than it is being supplied by the roots. Determine the cause of wilting. There also are many insects and diseases that affect leaves.

A. Drought

1. Symptoms—Wilting, drying of soft growth, and blotchy necrosis.
2. Causes—Extended periods of dryness. High heat/bright sunlight on shade-loving plants could cause leaf scorch, early leaf drop, or marginal and interveinal chlorosis or necrosis.
3. Remedies—Water plant; provide better soil preparation by adding organic matter to increase water-holding capacity; mulch to reduce surface evaporation. Select drought-tolerant plants. Shade plant; mist periodically for temporary cooling.

B. Frost Damage

1. Symptoms—Partial to total necrosis of young leaves or buds. Older leaves may become distorted if buds were injured.
2. Causes—New growth frozen by late spring frost when the plant is in the soft growth stage.

C. Root Injury

1. Symptoms—Wilting, early leaf drop, leaf chlorosis, root damage, necrosis, and plant death.
2. Causes—Root damage due to trenching, insects (such as root weevils), or disease. Overwatering limits oxygen uptake by roots and encourages root rot.

3. Remedies—Determine the cause, then take appropriate action. If the cause is not a root rot, then proper watering of the remaining root system will help. Fertilization with a high phosphorus fertilizer may help rejuvenate the root system. If overwatering is the problem, increase drainage and cut back on water. If a high water table or poor drainage exists, choose water-loving plants (such as a willow).

D. Vascular System Injury
   1. Symptoms—Wilting or drying of a portion of the plant.
   2. Causes—Disease, such as Verticillium wilt, can plug the xylem vessels.
   3. Remedies—Determine the cause and take appropriate action. Remove the infected portion; treat for Verticillum.

E. Salt Damage
   1. Symptoms—Marginal to interveinal chlorosis/necrosis; rootlets are brown instead of white.
   2. Causes—Salts from excessive use of commercial fertilizers, manures, and deicing salts. The latter may be more prevalent next to sidewalks and driveways.
   3. Remedies—Leach with water, if possible; limit the use of offending materials. Alternate organic fertilizers with commercial fertilizers to reduce salt buildup.

F. Leaf Chlorosis and Nutrient Deficiencies
   1. Nitrogen deficiency.
      a. Symptoms: Overall yellowing of **older** leaves first. Stunted growth of plant. Pale green color on rest of plant.
      b. Cause: Nitrogen deficiency.
      c. Remedy: Fertilize with a nitrogen fertilizer.
   2. High pH (over 7.5).
      a. Symptoms: Interveinal chlorosis, light green to white in color (with zinc, older leaves affected; with iron, new leaves affected first). The margins of leaves may become necrotic, but the veins remain green. With zinc deficiency, leaves may be small, narrow, and thickened. Foliage loss may be early, and leaves at tips of branches may be bushy with few or none along the branch. Manganese deficiency is similar to iron deficiency, but chlorosis is not so dominant on young leaves. Also there is severe browning and dropping of leaves with maturity.
      b. Cause: Iron, zinc, or manganese deficiencies because of the soil pH.
      c. Remedies: A long-term solution is to decrease soil pH. A temporary solution is to apply the deficient nutrient. You may need to make annual spring or fall applications.
   3. Other causes of leaf chlorosis.
      a. Wrong soil pH for acid-loving plants. Example: azaleas.
      b. Herbicides (see Subsection G of this section and Table 1).
      c. Drought (see Section VI, subsection A).
      d. Natural leaf maturity and abscission in autumn.
      e. Natural variegation.

G. Herbicide Damage

   Herbicides are formulated to be toxic to specific weeds, but they also may cause damage to desirable plants.
   1. Symptoms—Some herbicides act hormonally and produce a twisted, cupped, puckered, or distorted growth. Other herbicides inhibit photosynthesis and chlorophyll formation, causing a peculiar coloration or characteristic chlorosis depending on the material used (see Table 1 on next page). In general, if many plants in one area are affected with unusual twisting, puckering, or with strange colorations and drying leaves, chemical or herbicide misuse may be the culprits. If only part of the conifer root system is affected by a herbicide, the damage may create a spiral pattern on the stem of the plant.
   2. Causes—Most people do not know where the root zones of desirable plants are; consequently, they overspray, and translocation of the herbicide into a desirable plant occurs.

3. Remedies—Almost all problems arise from misapplication and misuse. Few problems arise when label directions are followed closely and the broadcasted material is kept 5 to 10 feet away from the dripline of desirable plants. Spot treat weeds rather than broadcast when possible.

H. Insecticide Injury

1. Symptoms—Dormant oil will remove the waxy bloom that gives the blue cast to Colorado Blue Spruce Oils used on deciduous plants that have started to show green will burn exposed green tissue. Some insecticides, such as malathion, will burn leaves when applied during high temperatures.

Table 1. Common herbicides.

Herbicide	Damage symptoms
Dichlobenil (Casoron)	Broadleaf plants: Tip, marginal to interveinal chlorosis/necrosis. Sometimes more severe on leaves oriented toward the afternoon sun. Conifers: Needle tip chlorosis to necrosis.
Phenoxy compounds (2,4-D, MCPP, MCPA)	Broadleaf plants: Twisted, distorted leaves and stems. Blistering of bark on London Plane trees. Conifers: Misshapen, hooked needles.
Dicamba (Banvel)	Broadleaf plants: Twisted, cupped, distorted new growth, chlorosis, necrosis, death of stem tissue. Conifers: Distorted, twisted needles, needle necrosis from the **base** to the tip; club-shaped growth, needle distortion on pines.
Glyphosate (Roundup)	Broadleaf plants: Yellowing and necrosis of part or entire plant. New leaves do not develop correctly; they are skinny,strap-shaped, yellow.
Triazines (Atrazine)	Broadleaf plants: Marginal chlorosis.
Simazine (Princep)	Conifers: Tip chlorosis.
Chemical sterilants (many kinds)	Severe chlorosis, and necrosis, death if applied near the root system of desirable plants.

2. Causes—When used for insect and mite control on needled evergreens, dormant oil may cause burns, especially if the concentration is too high, if the oil is applied during freezing weather, or if the plant has started to grow.

Further Reading

Books

Partyka, R. E. 1980. *Woody Ornamentals: Plants and Problems*. ChemLawn Corp.

Harris, R. W. 1983. *Arboriculture: Care of Trees, Shrubs and Vines in the Landscape*. Prentice-Hall, Inc.

Booklets and Pamphlets

University of Idaho Extension

CIS 867 Cold Hardiness in Woody Landscape Plants: Its Role in Winter Survival and How to Maximize It

CIS 869 Controlling Sunscald on Trees and Shrubs

Published 1993. Revised 1998.

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Chapter 18
Woody Landscape Plants

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INTRODUCTION

Woody landscape plants are perennials with stiff, woody stems. These plants are loosely classified as trees, shrubs, or vines. Trees usually have a single trunk and can grow to impressive heights. The tallest trees are the California redwoods (*Sequoia sempervirens*), which grow to 350 feet or more. Trees can develop—or be pruned to grow—several trunks. If a mature single- or multi-trunk woody plant is less than about 20 feet tall, it is considered a large shrub rather than a tree.

Shrubs are less than 20 feet tall at maturity and usually have multiple trunks. Standards, which are shrubs trained to grow with a single trunk, may serve as small trees in the landscape. Because they had to be trained (pruned) to grow this way, however, they are still considered to be shrubs. Woody shrubs may spread by stolons (horizontal stems), rhizomes, or underground roots. Very short woody shrubs make good ground covers.

Vines may climb, trail, creep, or even remain erect with some support for their stems. Woody vines may root at various places along their stems, wherever they come in good contact with the ground and have proper growing conditions. Climbing vines, such as English ivy, may attach to supports with small aerial roots. Grapes can climb by winding slender stems called tendrils around objects.

Some plants will perplex the expert horticulturist and the Master Gardener by defying classification with the above system. Crabapples are a good example. Some insist on growing with multiple stems, yet grow taller than 15 feet at maturity. Others are natural, single-stemmed beauties, reaching only 5 feet at maturity. Some weeping forms, if grown on their own rootstocks, would creep across the ground. So, crabapples can be large shrubs, tiny trees, or even vines! Thus, use the tree, shrub, or vine classification only in a general sense.

THE ART OF DESIGNING LANDSCAPES WITH WOODY PLANTS

Woody plants form much of the structure in landscape design and contribute to a pleasing composition. They define the skyline and become the structural element dividing space. Landscapers must carefully consider choices and placement. Established trees and shrubs cannot be moved easily. Within the principles of landscape design (see chapter 16), woody plants serve the following purposes.

Balance. Tree and shrub placement, whether symmetrical or asymmetrical, creates equilibrium in the landscape. Trees and shrubs provide the coordinating composition for other elements, such as annuals, perennials, and garden features such as fences and decks.

Movement. Repeating or alternating shrubs and trees can carry the eye throughout the landscape. The rhythm created is an underlying theme of the landscape. Taller shrubs and trees draw the eye skyward.

Harmony. Trees and shrubs serve as a dominant feature or accent in a landscape, thus contributing to the harmony of the design. Repetition of structural elements, such as woody plants, helps to tie the landscape together. The interconnectedness of a low woody ground cover under trees or of a line of shrubs or trees provides continuity that creates harmony in the landscape.

Which woody plants to install and where

Plant selection is extremely important if the landscape design is to be successful. Of the many factors to consider when choosing plants, two are most important—size and site suitability. During most of its life, the plant must be of a size suitable for the location. Site suitability means that the plant is adapted to grow where it is planted.

Function, color, texture, shape, bloom date, rate of growth, and how well the plant relates to other elements of the design are additional important considerations. In recent years, special uses (e.g., theme gardens or patios) or adaptations (e.g., native plants or Xeriscape™) have become more popular. See the listing at right for a summary of plant uses and characteristics, as well as site considerations. See chapter 16 for landscape planning guidelines

The following landscape considerations apply specifically to woody plants.

Function

Choose woody plants with a specific function in mind, which may be as simple as providing shade. Some functions are as follows.

Firewise landscapes. Landscaping for fire prevention, or "firescaping," is particularly important for suburban and rural locations in dry areas near hillsides, or in narrow canyons surrounded by thick stands of trees and brushy open spaces. For a firewise landscape, clear brush from within 30 to 400 feet of dwellings and outbuildings. Select woody plants that resist fire or have low levels of oil or resin. Plants should have foliage with a high moisture content or low brush and litter potential. Avoid designs that place plants of different heights in the form of a "fire ladder." Fire ladders provide a continuous fuel supply from the ground up to the plant canopy.

Screening and barriers. Windbreaks, shelterbelts, woody plant borders, and screens are all made up of rows of woody plants of various shapes and sizes. Besides providing beauty, they reduce wind velocity, capture snow, stop erosion, and shelter wildlife. They also provide protection from unsightly views, disturbing sounds, dust, and, to some extent, atmospheric pollutants. The right sequence of woody shrubs and trees reduces high winds around the home, farmstead, park, or recreation area, while permitting breezes to enter.

Plant and site characteristics to consider when selecting woody landscape plants

Plant uses
Attract birds or other wildlife
Attract butterflies or hummingbirds
Bonsai
Borders
Container or patio plants
Edible parts or fruits
Espalier
Fast growth
Foundation plantings
Ground cover
Native plants
Rock gardens
Screen or windbreak
Shade
Variety of specimens
Vines for fences or trellises
Vines to cling to stone or brick
Understory for woodland setting
Weeping form

Plant characteristics
Colored summer foliage
Columnar, pyramidal, or globe shape
Decorative fruits and berries
Decorative or interesting bark
Fragrant flowers
Good fall color
Multiple trunks
Ornamental seed pods
Showy flowers

Site characteristics
Acidic soil
Alkaline soil
Arid sites
Dry or sandy soil
Heavy clay soil
Saline soil
Shady areas
Low-maintenance areas
Wet sites
Windy areas

Plant screens and barriers consist of one to eight rows of trees and shrubs. Where space permits, several rows of shrubs and trees of various sizes and habits, both deciduous and evergreen, can be used. To serve as a windbreak, the planting should be at a right angle to prevailing winds. Where drifting snow is a problem, the last row of the planting should be at least 60 feet from the home. Careful attention to the design of site entries and exits will prevent snow or soil from drifting onto access routes. Windbreaks must be carefully maintained to be effective and must be kept weeded, mulched, or cultivated. (See PNW 5, *Trees against the Wind*, for more information about windbreaks.)

Energy efficiency. Trees can reduce utility bills and improve the comfort of your home. In summer, trees on the southern and western sides of structures can block hot sunlight, thereby reducing the need for air conditioning. In winter, these same trees—if they are deciduous (lack leaves in winter)—allow the sun's rays through to warm your house. Blocking cold winter winds with shelterbelts can also reduce heating expenses, especially in homes with poor insulation or air leaks.

Xeriscape™. In a xeriscape, drought-tolerant plants are chosen in order to conserve water. With this approach, all of the plants in a given area must have the same water-use requirements to obtain maximum irrigation efficiency.

Native plants. Plants naturally growing in our region are becoming increasingly popular in Idaho landscapes. Native plants are adapted to existing climatic conditions and bring a rich diversity of texture and color to home gardens. They often have lower water demands, fewer pest problems, and lower fertilizer needs than non-native landscape plants. For naturalized plantings, native species often are the best selection, and they should be the first choice for conservation plantings and ecosystem restoration.

Keep in mind that even native plants need adequate water, especially right after being planted. After plants are established, you can reduce water to those that thrive in the wild with little moisture. The goal is to duplicate the growing conditions of the plant's natural habitat.

When using native plants, purchase them from a reputable nursery rather than collecting them from the wild. Wild collection puts pressure on wild plant communities and introduces diseases and insects found in the wild to your yard. The one exception to this rule is rescuing or salvaging plants that are facing destruction by construction.

In order to have well-adapted native plants, use plants propagated from those growing as close to your landscape as possible. This step will also help prevent degradation of the gene pool of local native plant populations.

Growth characteristics

Growth characteristics of woody plants influence their ability to fulfill a specific function in the landscape.

Exposure. Select woody plants according to their preferred exposure in the landscape. Plants may be labeled (1) full sun/partial shade, (2) partial sun/full shade, or (3) shade. Check the plant species in several references to learn the range of exposures suitable for a plant. Some species can grow under many conditions, but specific cultivars may tolerate only one type of exposure.

Growth rate. Woody plants are designated as slow, medium, or fast growers. The rate of growth refers to vertical increase unless specified differently.

Growth habit. Woody plants can grow prostrate, horizontal, or upright. They can be dwarf or standard in size. Growth shapes include round, globe, vase-shape, pyramidal, and columnar (figure 1, page 5). Some cultivars are selected for weeping or contorted forms. Plant propagators select these growth habits and plant shapes for artistic, space-saving, or landscape purposes.

Foliage density. Most coniferous evergreens and some deciduous trees and shrubs have very dense foliage; thus, their shadows form dense shade, affecting growing conditions beneath the tree. Trees with dense foliage are very effective at blocking unpleasant views. Most deciduous trees create filtered shade, and distant views can be glimpsed through their foliage.

Crown size and height. Knowing the approximate size of trees, shrubs, and ground covers at maturity allows the landscaper to plant them where they can develop to their full extent. Plant descriptions state general height and spread (width) of a plant, based on average growing conditions. However, mature height and spread are greatly influenced by the length of the growing season, temperature, light, water, soil type, fertility, and

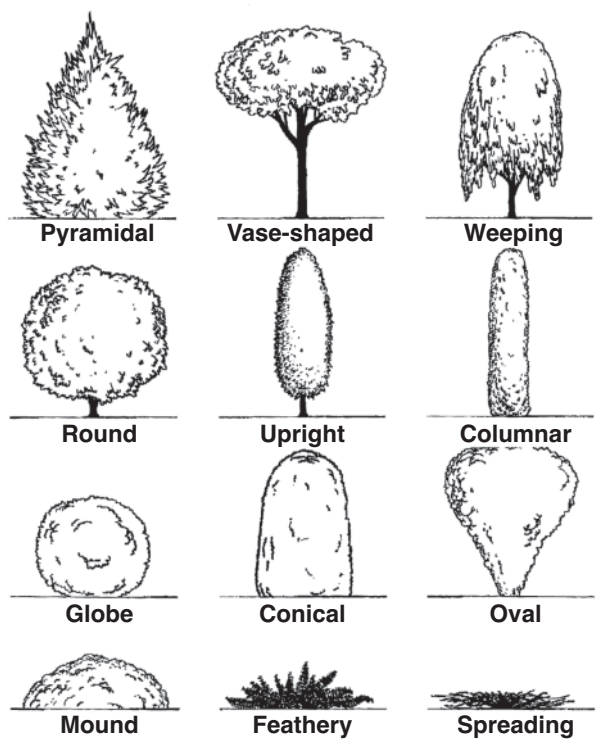


Figure 1. Plant growth habits and their resulting shapes.

other factors. Variation in these factors makes predicting the exact mature size of a plant very difficult. Be sure to compare the mature height listed on the retail sales tag or in reference books with the actual height of plants growing in your area.

Trees, shrubs, and ground covers can be categorized by height into the following groups: large trees (50 feet and over), medium trees (25 to 50 feet), small trees (under 25 feet), large shrubs (8 feet and over), medium shrubs (5 to 8 feet), small shrubs (3 to 5 feet), very small shrubs (under 3 feet), tall ground covers (under 2 feet), and short ground covers (under 1 foot).

Longevity. Short-lived trees and shrubs often grow quickly and provide height and bulk in a short period of time. They may be susceptible to pests and weather-related problems, however. Long-lived species have strong trunks and sturdy, wide angles of branch attachment. They tend to tolerate winter storms, pests, and human damage.

Hardiness zones. Select plants adapted to your climatic zone. Several types of hardiness zone maps can be found in references and on the Internet. The most common is the map developed by the USDA (see figure 1, chapter 16, page 16-3 for Idaho USDA hardiness zones). The USDA hardiness zone map is revised from time to time, and the latest revision was completed in early 2012. Other maps include the Arnold Arboretum Hardiness Zones, the Sunset Western Garden Book Climate Zones, and the heat zone map of the American Horticultural Society.

Whichever map you use, the zone concept is a useful tool that can provide an idea of how well adapted a plant is to your climate. When choosing woody plants that will be long-lived, dominant features of your landscape, choose plants that tolerate extreme climatic events. To be safe, choose only woody plants adapted to one zone colder than your zone.

Salt tolerance. Salt accumulation plays an important role in woody plant growth and survival. Too much salt in the soil interferes with a plant's ability to take up water, causing leaf burn and decline. Even salt-tolerant plants will fail to grow where salt levels are high. Plants native to a region have adapted to existing salt conditions in the local soil.

Several sources are responsible for contributing salts to the soil. In arid regions, soluble salts accumulate at the depth to which soil moisture soaks each season. These salts can be brought to the surface with irrigation. Also, if water sources contain high levels of salt, woody plants can be injured. Salt used for winter ice removal on roads can also cause problems.

Ornamental characteristics

Ornamental characteristics of a plant, such as flowering, fragrance, foliage color, foliage texture, etc., must be considered by gardeners and landscapers during the selection process (see listing page 3). Although these characteristics are important, however, plants must first be selected based on their adaptation to a site. A plant that is growing poorly due to its inability to adapt to a site will most likely have poor flowers, poor foliage color, etc.

The style of the garden needs to be considered as well. Whether the garden is cottage, Mediterranean, tropical, oriental, formal, artistic, avant-garde, rustic, naturalized, or native plays a key role in the types of woody plants selected. Finally, how the garden will be used and maintained should also guide design and plant decisions.

Plants that accent, define boundaries, and/or are a special feature in the landscape must be selected with specific goals in mind. Numerous landscaping books, computer programs, and publications can assist in the plant selection process (see "Further Reading and Resources" at the end of this chapter). More on arranging the form, shape, and space of woody plants is covered in chapter 16.

Genetic adaptability

Plant hardiness is genetically determined. The genetic makeup of plants enables them to grow and thrive under certain environmental conditions and completely fail in others. Therefore, plant provenance, the area where plants were collected before propagation, influences their ability to adapt to new locations and climates.

Many plants are adapted across several climatic areas or hardiness zones. However, for native plants that are propagated from seeds, plants from more southern seed sources are generally less hardy than those propagated from northern seed sources. For example, red maple, *Acer rubrum*, is a native tree that grows from Florida to Canada. Trees grown from a southern seed source will be less hardy than those grown from a northern source. The same might be said for plants grown on the East Coast and then planted in the West. Plant adaptability is often called plasticity among professional horticulturists and should be considered in selecting woody landscape plants.

Site considerations

Complete a landscape site analysis. This analysis should include climate, soil type, water availability, hardscapes (non-plant elements such as sidewalks, patios, decks, pools, etc.), utility locations, aspect (direction the landscape site faces), access, etc. Landscape site analysis is covered in chapter 16.

When choosing plants, various types of insect and disease pests (bronze birch borer, Dutch elm disease, etc.) must also be considered. In order to minimize maintenance and the need for pest control, selecting the right plant for the existing conditions is essential. Even features such as dropped fruit, seedpods, or resulting seedlings must be considered.

If your soil is poorly drained, select plants adapted to wet soil conditions. Improve surface drainage by changing the grade or trenching. Root zone aeration can help prevent puddle formation and runoff. If simple aeration (poking holes at regular intervals) fails to improve soil drainage, drill holes 6 to 18 inches deep before planting and backfill them with sand or pea gravel. This procedure is called vertical mulching. In extreme cases, install drain tiles to carry excess water away from the site.

GETTING STARTED WITH WOODY PLANTS

As discussed above, the planning stage should include finding woody plant species that will grow in your area and will serve your landscape needs. Make a scale drawing of your site to provide a basic plan that you can use and update. Since trees and shrubs are essential elements of this plan, choose and buy them wisely and then plant them properly so you can have years of pleasure.

Purchasing woody plants

Plants can be purchased from local garden centers, retail outlets that seasonally bring in wholesale nursery stock for resale, mail-order companies, farmers' markets, nursery cooperatives, or at special plant sales sponsored by service or gardening organizations. Select only vigorously growing plants that have a healthy appearance and are correctly labeled. Inspect all plants for insects, diseases, or poor growth structure before you purchase them or right after they arrive (if mail ordered). If a plant is grafted, check the graft union. Purchasing healthy, pest-free plants will allow you to avoid having to treat your plants or quarantine them before planting them into your landscape. The goal is to avoid introducing new pests or problems into your landscape.

Beware of "good deals" at the end of the summer, for these plants may be stressed or root-bound. If gardening friends offer you plants that fail to fit your landscape plan, are in poor health, or might become invasive, have the courage to decline their offer.

Local retail garden center personnel know the planting dates for your area and have experience with species and cultivars suited to local needs, as well as with common problems in your area. They have selected plants that are adapted to your climatic conditions and soils. In many cases, local garden stores are willing to special-order plants. In addition, they often guarantee the plants they sell. If you personally select your plants, have your plan and plant list in hand when you visit the garden center.

Be open to new ideas and plants suggested by plant professionals.

Plants can also be purchased from discount, hardware, drug, convenience, grocery, or produce stores. However, plants at these stores may not be appropriate for your landscape. Prices are often lower due to volume discounts, but the species may not be adapted to your area, and the plants' condition may be poor due to a lack of proper maintenance.

Mail order is another alternative for purchasing plants. Check catalogs carefully to make sure the plants meet all the criteria in your landscape plan. Mail-order plants will be bare-root or container-grown. They may be small, but if shipped correctly and planted promptly, these plants generally survive and grow well. When ordering over the phone or by mail order, ask about returning plants if their quality is low. Many mail-order nurseries guarantee the plants they sell.

Service organizations, garden clubs, schools, and public agencies occasionally hold special plant sales. These sales provide great opportunities to obtain rare or prized woody plant species from local sources.

Planting woody shrubs and trees

The techniques required for successful transplanting of woody plants depend on the kind of plant; its age and size; whether it is dormant or growing; its nutritional status; whether it is nursery-grown, growing around the home, or a native plant; whether it is adapted to the selected site; and the site conditions and climate of the area. For more information, see chapter 17.

Newly transplanted trees may be staked if necessary. The main reasons to stake a tree are to hold its canopy upright if the trunk is weak or to prevent the root system from moving and breaking roots. The goal for staking a tree is to allow the trunk to flex while the roots are held in place. Trunks grow strengthening "reaction wood" when they move back and forth in the wind; thus, be sure the trunk is free to move in the wind but held securely enough to prevent the root system from moving. Secure the tree to two or three stakes placed at least 12 to 18 inches from the trunk (figure 2). Use broad, smooth material, such as nylon straps, to attach the tree to the stakes, since this type of material will not damage the trunk. Tie the trunk as low as possible to hold the tree upright on a calm day. Remove staking materials as soon as possible and no later than 1 year after planting.



Figure 2. Proper staking of a tree involves attaching two or three stakes as low as possible on the trunk. The objective is to hold the tree roots in place yet allow the trunk to flex in the wind. Notice the broad strap material connecting the trunk to the stakes. Photo by Kaitlin Moroney.

First-year care

The first year in a new site is critical for transplanted woody plants. Survival is determined by care and conditions, and a good start helps a landscape planting fill in quickly.

Water new plants to a depth of at least 2 feet during each irrigation. Light, shallow watering fails to provide enough water to develop a wide, deep root system, and it may promote accumulations of harmful salts. The amount of water needed to fill the soil to a depth of 2 feet depends on the soil type; sandy soil holds less water than clay soil.

Soil type and drainage determine the frequency of irrigation, but, generally, watering is required every 5 to 7 days. Soil should drain and dry between irrigation cycles to maintain adequate oxygen levels in the root zone and to reduce the possibility of development of root rot diseases. New plants will wilt in saturated soil due to a lack of oxygen around the roots.

Fertilizing woody plants during the first growing season may be unnecessary and can be harmful. Excess fertilizer salts in the root zone damage the limited root system of a newly installed plant. Plants generally need a season to establish a vigorous root system before fertilizer promotes more foliage growth.

In general, plants with fibrous roots and root hairs (container-grown and balled-and-burlapped plants) could benefit from a light fertilizer application, as their root hairs can absorb the minerals and avoid wasting nutrients. Plants that lack root hairs at planting time (bare-root plants) may be unable to absorb nutrients from fertilizer applied to the soil. Nutrients may remain in the root zone or leach (wash) away, wasting minerals and money. Therefore, use fertilizers carefully at planting time. If using a fertilizer, be sure the product is labeled for use on newly transplanted shrubs or trees.

You can protect newly planted shrubs and trees from the wind by erecting a barrier of burlap or other material. Wrapping plants with narrow, upright branches, such as arborvitae, in winter can prevent damage caused by snow accumulation. Avoid using plastic for wrapping because temperatures get too hot under the film.

For species sensitive to cold temperatures, bury small or horizontal plants in leaves or loose, unfinished compost after the first frost. Keep in mind, however, that burying small, tender plants can encourage disease development or rodent activity. Therefore, periodically check buried plants during the winter. If you see problems, take appropriate actions to eliminate them.

MAINTENANCE OF WOODY LANDSCAPE PLANTS

Irrigation

Proper watering of woody landscape plants is probably the most important factor to promote plant growth, beauty, and health. For more information on water management, see chapter 7. The amount of water used by a woody plant is determined by species, size, air temperature, relative humidity, wind, and light intensity. A hot, sunny, dry, windy day can cause a lot of water to be transpired by a large tree. Many sites in Idaho have just such conditions.

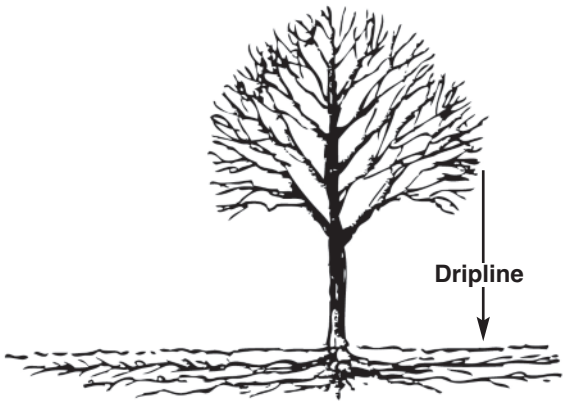


Figure 3. Dripline on a deciduous tree.

The water-absorbing roots of trees (feeder roots) grow mostly in the top 12 to 18 inches of soil. Their distribution extends well beyond the dripline (figure 3). Apply water over the entire absorbing zone. If practical, expand water-holding basins around the base of plants on a yearly basis to accommodate the previous year's growth.

Irrigate to wet the soil to a depth of at least 2 feet. The amount of water needed to fill this soil depth depends on the soil type; sandy soil holds less water than clay soil.

As with newly planted trees, avoid keeping the root zone saturated in order to allow proper root aeration. Avoid shallow, frequent irrigations because this practice encourages shallow and limited root development.

Irrigation methods

Flood irrigation provides an infrequent, deep soaking. You can achieve the same result on a small scale by flooding the basin around the base of a tree or shrub using a bubbler hose attachment. This type of watering is the most efficient method of irrigation for isolated plants.

Sprinklers are the most common method of irrigation. Be sure to apply enough water to soak the root zone of trees and shrubs. *The amount of water needed for the shallow roots of a lawn will not be enough for trees and shrubs.* Sprinkling the foliage of trees and shrubs can increase the potential for some diseases. Minimize this risk by watering early in the morning (by 10 a.m.) so the plant can dry during the day. Early morning watering also improves watering efficiency.

Drip irrigation systems are extremely efficient and provide a slow source of water. They work better with heavy soil than with sandy soil. Apply water away from the trunk and in the area of water-absorbing roots. As the plants grow, update drip systems by adding more lines or emitters to provide enough water for the larger plant and root system.

Winter water management

Where winters are cold and the ground freezes, take special care to make sure woody plants enter the winter completely dormant and with an ample supply of subsurface water to get through the winter. Gradually withhold water after mid-September by applying less water or irrigating less frequently for 4 to 6 weeks. Withholding water slows plant growth and helps the plant enter a dormant state.

Sometime just before the first hard freeze (often October 15 to November 1), irrigate the soil thoroughly. Add enough water to wet the root zone down to about 18 inches. Most of this moisture will be available to the plant roots beneath the frozen layer of soil during the winter. Fall watering is particularly important for evergreens, due to the amount of water that needles and leaves can lose on a sunny winter day.

Mulching

The benefits of a mulched area around trees and shrubs are five-fold: (1) elimination of competition from weeds and grasses, (2) conservation of soil moisture, (3) moderation of soil temperature, (4) protection of plants from lawn mower and string trimmer damage, and (5) growth of a more extensive root system.

Good mulches include coarse compost, bark chips, rocks, or gravel. Use of very fine or less permeable mulches, such as sawdust, may encourage shallow rooting.

The mulch layer should be 2 to 3 inches deep and can extend to the dripline of the tree. Keep mulch away from the plant's trunk or stems to reduce the possibility of crown rot or animal burrowing. Installing permeable landscaping fabric beneath the mulch will help control weeds. Avoid using non-perforated plastic since it reduces water and air infiltration in the root zone.

Symbiotic relationships

Roots of many trees and shrubs form symbiotic relationships with fungi or bacteria. Symbiotic relationships are those in which both parties benefit. For example, mycorrhizal fungi live around, and sometimes in, plant roots, obtaining carbohydrates, vitamins, and other organic compounds from the plant. The soil in the root zone area, known as the rhizosphere, is more hospitable to nutrient absorption by plant roots because of the fungi's presence. Mycorrhizal fungi may enhance a plant's tolerance of environmental extremes and its resistance or tolerance of pathogens. Many of the "mushrooms" seen in the landscape at some distance from trees are fruiting bodies of mycorrhizal fungi.

Commercial products containing a mixture of mycorrhizal fungi can be mixed with the soil when planting trees and shrubs. Although mycorrhizal spores are found in most soils, preliminary studies indicated that commercial products may speed the establishment of a symbiotic relationship. Be aware, however, that most research has shown that these products have had limited success inoculating roots of woody plants in landscape situations. More research is needed to prove the value of mycorrhizal fungi inoculations.

On some woody plants (typically species in the legume family), specific bacteria induce formation of nitrogen-fixing root nodules. Black locust, alder, ceanothus, and Russian olive, for example, are able to transform atmospheric nitrogen into a form that is usable for their own growth and for that of nearby plants. This capability enables these species to grow on nitrogen-poor sites.

Fertilizing

Woody plants require essential elements to function. However, too much nitrogen can promote excess growth that requires more pruning and water and increases pest problems. On coniferous evergreens, a "spurt" of growth in reaction to fertilizer can create whorls of branches farther apart at the top of shrubs or trees and on the branch tips, detracting from the symmetry of the plant. If a woody plant is healthy, lacks nutrient deficiency symptoms, and grows at a satisfactory rate, it probably needs little, if any, fertilizer. (See CIS 1068, *Fertilizing Landscape Trees*, for more information, including fertilizer rates.)

PRUNING

The basics

In the home landscape, trees and shrubs usually have ample light and space, so they produce many branches and grow to a maximum size. Proper pruning shapes or directs growth of plants into appropriate and beautiful forms, while maintaining and augmenting plant health and function.

Reasons for pruning

Plants are pruned for a number of specific reasons. Training young trees and shrubs (in other words, directing plant growth) to create attractive shapes and a strong structure is a good reason to prune. Prune mature plants to remove dead, diseased, hazardous, or unsightly branches. Pruning to maintain a central leader on a tree is sometimes necessary, as is removal of branches that interfere with activities and structures. Pruning can enhance flowering and fruiting. It can also open up a tree or shrub for less wind resistance and better light penetration. Shrubs may need pruning to create a fuller look or to maintain a special shape or form, such as for hedges.

Pruning plants to limit their size (height and width) is a legitimate reason to prune, but only minor amounts of pruning should be used for this purpose. A woody plant too large for its growing space cannot be made small by pruning! Drastic pruning—removing large amounts of branches or severely reducing the heights of tall trunks—results only in temporary size reduction, can be expensive, and is damaging to the plant. Plants pruned severely to reduce their size will be badly misshapen when they regrow, and new branches may be weakly attached and break during wind stress or under snow loads. The best solution is to remove the oversized plant and replace it with one whose mature size is more suited to the growing space.

Pruning tools

Proper tools are essential for satisfactory pruning (figure 4). If possible, test a tool before you buy it to ensure it suits your specific needs. As with most things, higher quality tools often cost more than cheap tools.

The choice of which tool to use depends largely on the size of the branches to be pruned and the amount of pruning to be completed. Hand pruners (pruning shears) are usually used to cut branches



Figure 4. Tools used to prune woody plants include (a) by-pass hand shears, (b) by-pass loppers, and (c) hand saws. Photo by Robert Tripepi.

one-half inch or less in diameter. Loppers can be used to cut branches from one-half inch to 1 inch in diameter. A pruning saw is used to cut branches 1 inch or larger in diameter.

If cutting a branch with hand shears is difficult, avoid twisting or bending the branch or tool; instead, use a larger tool, such as loppers. Some loppers have a ratchet mechanism, enabling branches larger than 1 inch in diameter to be cut easily. However, even though the branch cuts easily, these loppers often crush branch tissues in the cut area. Therefore, using a pruning saw on branches larger than 1 inch in diameter often results in a better cut and less damage to the plant tissues.

Types of pruning cuts

Two types of basic pruning cuts are thinning cuts and heading cuts (figures 5 and 6, page 11). Keep in mind, however, that several types of heading cuts (for example, shearing or stubbing) can be made, and two types of thinning cuts can be used.

Thinning cuts. Thinning cuts are often the preferred type of pruning cut for landscape trees and shrubs. One type of thinning cut removes a branch or stem at its point of origin. This type of cut opens up a shrub or tree and reduces the weight of limbs. These cuts avoid stimulating new growth and help retain the natural shape of the plant. They are made at a location on the stem where wounds can be grown over quickly, thus preventing decay fungi from spreading in the wound.

The second type of thinning cut is called drop-crotch pruning, which reduces the overall height of

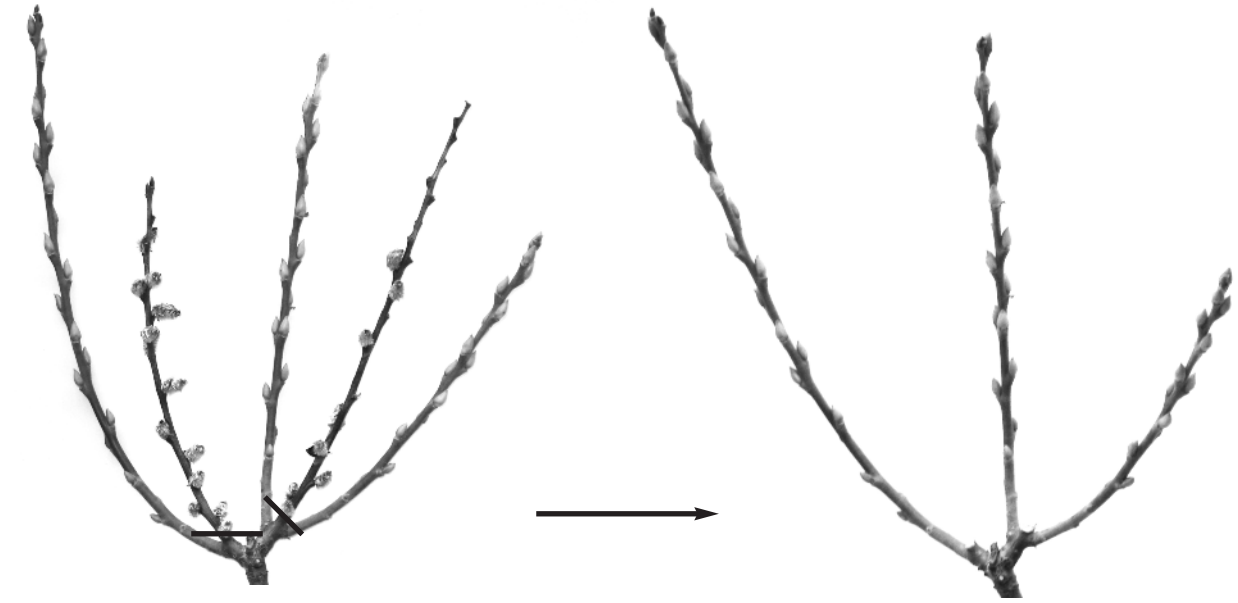


Figure 5. Thinning cuts on willow. Note that the stems are cut at their point of origin on a larger stem. Photo by Robert Tripepi.



Figure 6. Heading cut made close to a bud on a branch. Note the closeup view of the angled cut above the bud (far right). Photo by Robert Tripepi.

a plant or length of a limb (figure 7, page 12). This type of pruning removes a branch back to a lateral branch large enough to assume the terminal role. This means that the remaining lateral branch can exert apical dominance, i.e., it can suppress growth below the cut, thus preventing latent buds from growing farther back on the branch. The lateral branch should be at least one-third the size of the branch removed. In other words, to remove a branch 6 inches in diameter, cut it back to a branch that is at least 2 inches in diameter.

Heading cuts. A heading cut removes a branch to a stub, a small bud, or a lateral branch not large enough to assume the terminal role. This type of cut usually induces branching and bushiness (increased branch density) below the cut. Heading cuts are commonly used for fruit trees, but often are inappropriate for woody landscape specimens, especially trees. Numerous vigorous upright shoots can arise below the cut, especially on larger branches, altering the tree's natural form.

Topping. Topping is a type of heading cut that involves cutting all major vertical trunks or branches back with heading cuts. This practice forms large stubs at the ends of the trunks. Topping a tree is an unacceptable pruning practice. It results in an ugly, deformed tree with many branches that often are weakly attached. These trees often become infected with decay organisms and are highly susceptible to insects and diseases. Within a few years, a topped tree often grows back to its original height because of bushy, invigorated growth, but it will be poorly shaped, as well as hazardous, due to its many weakly attached branches. The only instance in which topping is acceptable is for a storm-damaged tree.

Topping a coniferous tree results in multiple leaders or a flat top—in any case, the natural shape of the tree is destroyed. The older the tree is at topping,

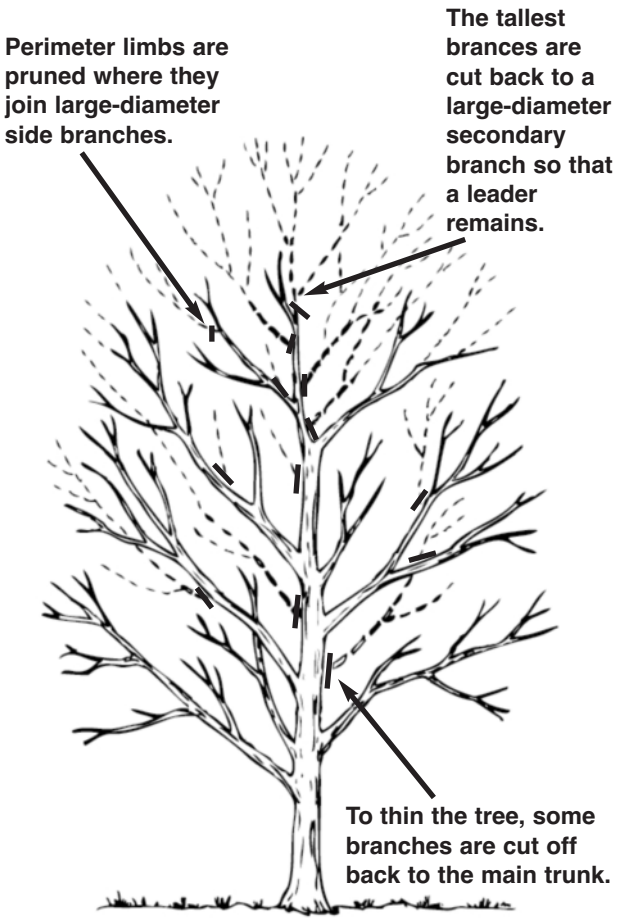


Figure 7. Drop-crotch pruning reduces the size of a tree without inducing vigorous new growth. Source: Colt, W. M., R. R. Tripepi, R. L. Mahoney. 1999. How to Prune Deciduous Landscape Trees. Bulletin 819. University of Idaho Extension, Moscow.

the less likely a lateral branch near the pruning cut will become a new leader. Although the tree may look healthy, research has shown that serious decay often develops at the wound site. This decay moves down the trunk, creating a hazardous tree.

Timing of pruning

The timing for pruning woody plants is important and depends on the type of plant and the purpose of pruning. You can do light pruning (removing small numbers or sizes of branches) or remove dead wood at any time of the year.

Except for pines, pruning coniferous evergreens during the dormant season can stimulate regrowth. To stimulate vigorous spring growth on fir, Douglas-fir, and spruce, prune these plants in late winter, when the plants are dormant. Pruning cuts will be covered by new growth later in spring, making the plant look more natural.

On these species, you can also prune off part of the new growth while it is still growing. Pruning at this time of the year will reduce the length of new growth and encourage branching. However, it usually stunts plant growth. Pruning after the annual flush of spring growth will maintain size and preserve atypical, or clipped, forms. On these species, you can also make heading cuts back to visible buds or light thinning cuts at any time.

Pine species are pruned at a specific time of the year. Pines form buds only at the tips of branches. If new growth (candle) is pruned after the growth flush is completed and the terminal bud is well formed at the end of the branch, new buds will fail to form and regrowth is impossible. Prune or pinch candles when their new needles have expanded to about half the length of the mature needles on the previous year's branches. Pruning candles at this time allows buds to form near the cut branch surface for the following year and allows the new growth to be more compact.

Some plants, such as maples, walnuts, birches, and grapes, may bleed when pruned just before or during sap flow. Although unsightly, this does no harm to the plant and will stop as the season progresses.

Some plants, such as *Potentilla* sp., bloom on the current season's growth (new wood). Prune these species during the dormant period, usually in late winter or early spring. Wait until the coldest part of the winter has passed, but prune before buds swell.

Other plants, such as lilac and forsythia, bloom on the previous year's wood. To avoid reducing the number of flowers on these plants, prune these species in early summer, within about 2 months after the flowers fade. On these species, flower buds form in late summer and early fall. Thus, winter pruning decreases the number of flowers the following spring by removing branches containing flower buds.

The listing on page 13 indicates bloom time of some flowering shrubs. For other species, check reference books. If you are unable to find a reference for your plant, use the flowering date of the plant as a rough estimate. For most areas of Idaho, plants that bloom before June 1 formed the flowers the

previous year on old wood. Those that bloom after June 1 form flowers on new growth. Keep in mind that this is only a rough guideline.

Also keep in mind that on any plant, pruning after flowering will remove fruits that would have formed.

Summer pruning, completed after spring growth has stopped, slows the development of a plant or branch. Plant growth is slowed because of reduced photosynthetic capacity (fewer leaves). Reduced photosynthesis means that less food is manufactured and sent to the roots for their development and for next year's growth. Prune in the summer cautiously, as summer pruning can weaken the tree or shrub, perhaps severely.

Avoid pruning in late summer. Any new growth stimulated by late-summer pruning can be susceptible to frost damage if it fails to harden before cold temperatures affect the plant tissues. Pruning can be completed in fall after plants are well on their way to becoming dormant—late September at the earliest.

The threat of introducing diseases into pruning wounds is higher in fall than in winter since more fungal spores are in the air in the fall. Pruning in late fall (late November) reduces the potential for fungal spores, particularly those of wood-rotting fungi, to contact pruning cuts. Avoid pruning frozen branches or stems (woody tissues) since the wood may crack, making the wound larger than desired.

Where to make pruning cuts

The location of a pruning cut depends on whether it is a heading cut or a thinning cut. Make heading cuts about one-quarter inch above a bud or small lateral branch and slant the cut away from the bud or branch (figure 6, page 11). Heading cuts made to the middle of a branch and not to a node will often induce a latent bud to grow from a node below the pruning cut. However, these cuts leave a stub on the branch. Avoid this practice, since these stubs are unsightly and may serve as an entry point for pests.

The base of a branch contains important tissues that help a plant grow over a pruning wound and prevent decay-causing microorganisms from spreading to the interior tissues of the stem or trunk. These important tissues are located between the bark ridge and the branch collar, collectively known as the branch shoulder. The bark ridge is usually a rough

Examples of flowering shrubs that bloom in spring (on old wood) or summer/fall (on new wood)

Spring-flowering shrubs

Azaleas, deciduous and evergreen (*Rhododendron* spp.)
Barberry, deciduous and evergreen (*Berberis* spp.)
Beauty bush (*Kolkwitzia amabilis*)
Brooms (*Cytisus, Genista* spp.)
Cherry laurel (*Prunus laurocerasus*)
Chokeberry (*Aronia arbutifolia*)
Cotoneaster spp.
Euonymus spp.
Daphne spp.
Dogwood, shrubby (*Cornus* spp.)
Flowering almond (*Prunus triloba*)
Flowering plum (*Prunus cistena*)
Flowering quince (*Chaenomeles* spp.)
Forsythia spp.
Heather (*Erica* spp.)
Holly (*Ilex* spp.)
Honeysuckle (*Lonicera* spp.)
Kerria spp.
Lilac (*Syringa* spp.)
Magnolia (*Magnolia* spp.)
Mockorange (*Philadelphus* spp.)
Mountain laurel (*Kalmia latifolia*)
Oregon grape (*Mahonia aquifolium*)
Pieris spp.
Privet (*Ligustrum* spp.)
Pussy willow (*Salix* spp.)
Pyracantha spp.
Serviceberry (*Amelanchier* spp.)
Siberian pea shrub (*Caragana arborescens*)
Spiraea spp. (white-flowering species)
Viburnum spp.
Weigela spp.
Witchhazel (*Hamamelis virginiana*)

Summer/fall-flowering shrubs

Butterfly bush (*Buddleia davidii*)
Heather (*Calluna* spp.)
Heavenly bamboo (*Nandina domestica*)
Hydrangea spp.
Potentilla fruticosa
Roses, shrubby (*Rosa* spp.)
Rose of sharon (*Hibiscus syriacus*)
Spiraea spp. (pink-flowering types)
St. John's wort (*Hypericum* spp.)
Tamarix spp.

Carefully observe when flowers bloom for nonlisted species.

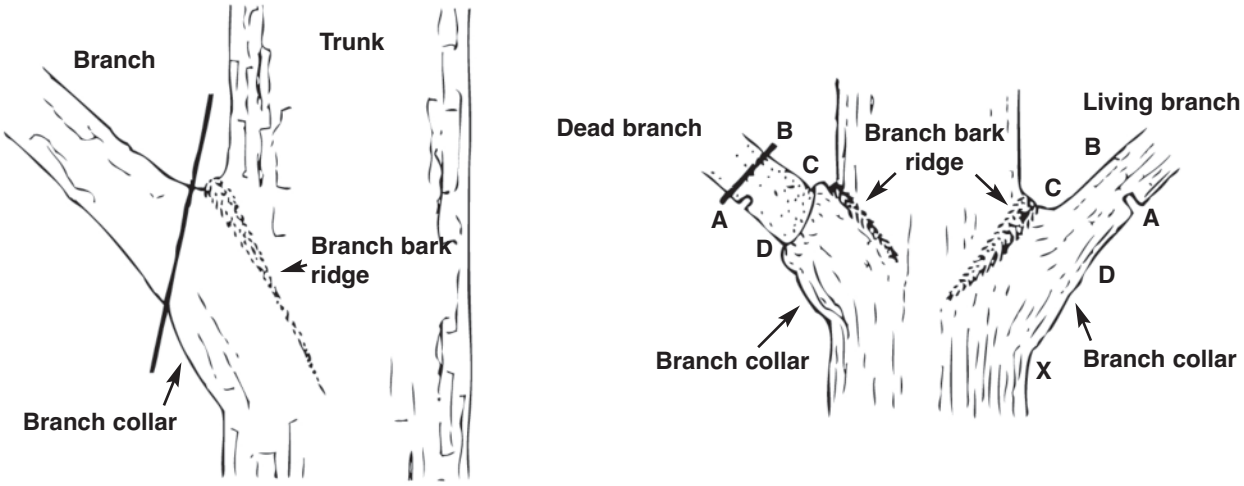


Figure 8. Proper location for thinning cuts. Source: Colt, W. M., R. R. Tripepi, R. L. Mahoney. 1999. How to Prune Deciduous Landscape Trees. Bulletin 819. University of Idaho Extension, Moscow.

patch of bark on the stem or trunk located just above the lateral branch that is being removed. On some shrubs or trees, however, the bark ridge may be thin and barely discernible. The branch collar is a slightly swollen area on the lower side of the lateral branch near its point of attachment.

When removing a branch at its point of origin (thinning cut), avoid wounding tissues in the branch shoulder area. Whether pruning live or dead branches, be sure to make pruning cuts outside the branch shoulder area (figure 8). For both types of branches, the final cut should be from point C to point D (figure 8), since cutting in this location is outside the bark ridge and branch collar. Avoid cutting from point C to point X. This type of cut is considered a flush cut, which can allow decay-causing microorganisms to enter the interior tissues of the stem or trunk. Also, pruning wounds are covered by new growth more slowly when flush cuts are made.

Be sure to hold the branch while cutting to prevent lower stem tissue from tearing. Tearing of stem or branch tissue causes a large wound that is covered slowly by new growth.

Branches larger than 2 inches in diameter may be too heavy to hold. Even when a smaller branch is pruned, its location may make holding the branch impossible while making the pruning cut. The likely result would be bark stripping. In these situations, use a three-cut method to remove the branches (figure 9, page 15). Make the first cut on the underside of the branch about 6 to 12 inches from the branch crotch. An undercut is used to prevent the bark from stripping or tearing due to lack of support when the cut is made. Cut about one-quarter of the way through the limb or until just before the saw binds due to the limb weight. If the saw blade becomes bound by a heavy limb, you most likely will be unable to lift the limb enough to free the saw blade.

Make the second cut on the top side of the branch, 2 to 5 inches farther out on the limb from the undercut (figure 9). Cut down until the branch drops off. Be careful to avoid being hit by the branch. It may move sideways as the limb cracks under its own weight until the crack reaches the initial undercut.

Make the third cut just outside the bark ridge/branch collar area. This final cut removes the stub and allows new tissue to grow quickly over the wound. Be sure to support the remaining stub while making the third cut; otherwise, the bark may tear, making the wound larger.

Wound dressings and pruning paints are cosmetic only. Research has shown that pruning paint or wound dressing usually fails to keep insects or diseases out of the pruning wound. They also fail to promote new tissue growth over the cut. In fact, some research indicates that these treatments may inhibit the wound covering process. Therefore, they generally are considered unneeded and a waste of money.

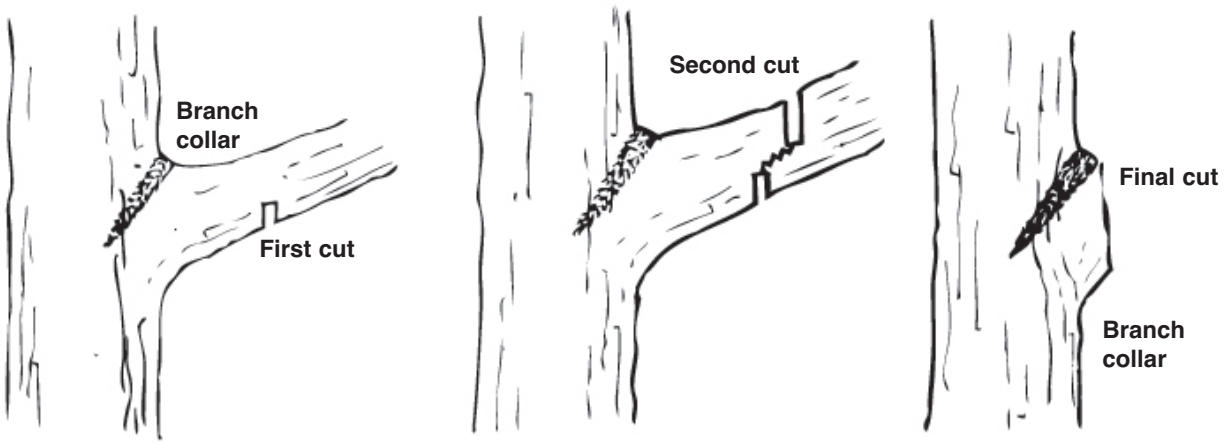


Figure 9. Three cuts are necessary to remove large branches or limbs that are difficult to hold by hand. Source: Colt, W. M., R. R. Tripepi, R. L. Mahoney. 1999. How to Prune Deciduous Landscape Trees. Bulletin 819. University of Idaho Extension, Moscow.

Special care when pruning coniferous plants

A latent bud is an inactive bud that will grow following a shock, such as pruning. Latent buds are distributed differently on conifer branches than on deciduous trees, limiting the amount and type of pruning that conifer species can tolerate without being permanently misshapen. See page 20 for information on pruning conifers correctly.

Early training of trees and shrubs

Early training of deciduous trees

Trees with good form have a longer life and less structural problems than trees that were allowed to develop a poor framework (scaffolding). By establishing a good framework early, a deciduous tree, such as a maple, will grow to fill its allotted space and should require minimal annual pruning.

This early pruning is known as training. Training involves directing tree growth into a desired shape and form. It should begin during the tree's second year. Train to create a tree that has a pleasing shape, with branches growing in the right direction for its space. Respect the natural growth habit of the tree when establishing an initial framework of branches. The mature shape (round, columnar, pyramidal, etc.) should be evident, even in a tree with only five or six branches.

Train the young tree to develop a central leader; strong branch attachment angles; a straight, strong trunk; and a good form. The central leader should be taller than any other branch. When a single leader (trunk) is obvious, remove some of the other branches (by using thinning cuts) to maintain the dominance of this branch.

Sometimes, however, a tree has many laterals that are of similar length. In this case, choose the trunk with the best placement to be the leader, and shorten the other lateral branches into a pleasing and appropriate form. When cutting out branches, maintain at least two-thirds of the plant as a live crown, since removing too many branches can damage or severely weaken a tree.

On a mature deciduous tree, scaffold branches, those branches that form the permanent structure of a tree, should be 12 to 18 inches apart. Choose branches that come off in different directions around the tree to create a balanced form and decrease competition for space and light. First remove any crossing and inward-growing branches. Then thin out (remove) selected lateral branches that compete for space and light. In other words, remove one branch if two adjacent branches arise from a trunk directly over one another. Next, eliminate any branches that grow in opposition to the natural form of the tree. Finally, thin any codominant branches (those that grow out from a single point, forming a Y) to a single branch, keeping the one that is most upright and has the fewest defects in its canopy.

Think about what the tree will look like when all of these branches get longer and larger in diameter, particularly branches with the potential to cause problems (rubbing branches, branches with limbs growing toward the center of the plant, etc.). Branches should be directed to grow to an area

where they can develop to maturity without pruning. Remember that branches do not move upward as a tree grows in height. If you are hitting your head on a 1-inch diameter branch now, in a few years you will still be hitting your head, but the branch may be 6 inches in diameter! Prune out problem limbs early.

A strong, well-tapered trunk can be developed by keeping some branches (called temporary branches) below the lowest permanent branch on your young tree. They will protect the young bark from sun injury, and their foliage will produce carbohydrates that add taper and strength to the trunk. Leave temporary branches in place for 3 or 4 years. Prune them to prevent them from becoming large and vigorous. After 3 or 4 years, remove them a few at a time over the next 2 or 3 years, beginning with the largest ones.

Branches should be strongly attached to the limb from which they arise. Strong branch attachment will allow limbs to tolerate ice, snow, and wind loads better than weakly attached branches and will help prevent the need for expensive pruning corrections later. The best branch angle attachment to the trunk is wide—ideally between 45 and 90 degrees (figure 10).

When crotch angles are very narrow, bark can become "trapped," or embedded, between the two branches as they grow. This situation is known as a bark inclusion. Where the bark is trapped, structural attachment is absent between xylem tissues in the two branches. As both branches become larger, the area of structural integrity (connected xylem tissues) becomes proportionally smaller, making the attachment between the two branches weak.

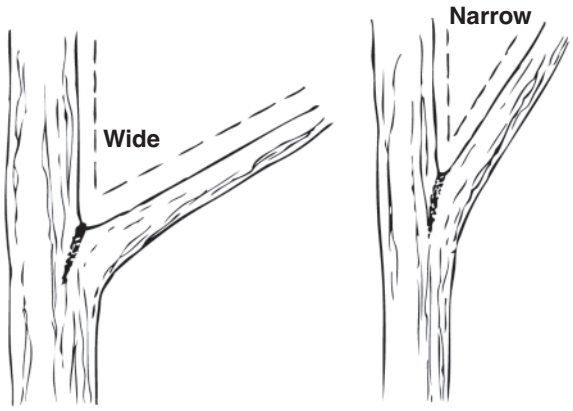


Figure 10. The angle of branch attachment should be wide, ideally between 45 and 90 degrees. Branches with narrow angles of attachment often develop "included" bark, making the branch attachment weak. Source: Colt, W. M., R. R. Tripepi, R. L. Mahoney. 1999. ***How to Prune Deciduous Landscape Trees*****. Bulletin 819. University of Idaho Extension, Moscow.**

Encourage a critically placed small branch with a narrow crotch angle to grow to a better angle by placing a stick or narrow board between the branch and the trunk to brace it open. Leave this brace in place until, when removed, the branch stays at the wider angle (figure 11). Several species of deciduous trees have narrow crotch angles and develop bark inclusions more often than coniferous trees. Avoid planting these species in areas with heavy ice, snow, or wind loads.

As young trees grow, prune to correct structural weaknesses and to remove dead, pest-infested, or broken branches. Remove rubbing branches since they result in wounds, decay, and notches. When choosing between rubbing branches, remove the most damaged branch with the narrowest crotch angle.

Other branches to remove include watersprouts and suckers. Watersprouts are rapidly growing, weakly attached shoots that form on trunks or limbs



Figure 11. Brace narrow-angle branches, bending them to a wider angle from the main trunk, and leave the support in place for at least 6 months. Photo by Kaitlin Moroney

above the ground or graft union. Suckers are rapidly growing branches that form on roots (below ground) or below the graft union. Both should be removed as soon as possible. Rubbing them off (rather than cutting) is possible when they are very young and helps to keep them from resprouting. If watersprouts or suckers have grown several inches, cut them off as close to the trunk or root as possible. The best way to prevent suckers from sprouting from the cut sucker is to dig into the soil and cut off the sucker where it arises from the root.

Early training of coniferous trees

Training conifers such as spruce, pine, and juniper takes special consideration. Many coniferous trees have pyramidal forms, regular whorls of growth, and tall, straight trunks. Conifers can develop multiple leaders, so maintaining a single central leader is important for developing a properly shaped mature tree. Remove all but one leader by using thinning cuts. Randomly branching conifers should be trained when the plants are young so they will develop attractively to fill their allotted space. Otherwise, coniferous plants need little training—unless the goal is to make a hedge or pruned shape (a topiary plant). See page 20 for more information about pruning conifers.

Early training of large shrubs

Some deciduous and broadleaf evergreen shrubs grow to a large size and have permanent scaffold branches. Examples are viburnum and magnolia species. Most coniferous shrubs, such as junipers, have permanent trunks and branches.

Essentially, these plants can be treated like small trees with multiple trunks, so establish their framework as described earlier. Train shrubs when they are young to direct plant growth so that the shrubs are appealing and have good branch structure. Begin pruning as the plant approaches its desired size, rather than after it is oversized.

Early training of hedges

A hedge is a row of closely spaced shrubs or trees, usually consisting of one species. Hedges can be grown informally as a row of natural-looking plants or formally with a lot of training and shearing. In both cases, minimize pruning right after planting and during the first year of growth. Training of the hedge will begin the second year after planting.

To produce an informal hedge, during the second year after planting, train and prune as with individual plants, striving to keep the plants similar in shape, density, and height. Pay special attention to keeping the foliage dense from the ground up. Train hedges to be wider at the base than at the top to prevent dieback of lower foliage due to inadequate light (figure 12).

With newly planted deciduous and broadleaf evergreen hedges, induce low, dense branching by heading back the entire plant by as much as half its height the second year after planting (in late winter or early spring). Use the same technique for yew and hemlock plants.

With other new conifer hedges, including spruce, juniper, arborvitae, and false-cypress, increase branching by pruning the tips of the new growth as, or just after, it elongates during the second year. Keep in mind that pines are an exception; prune new growth on pine species after the needles on the candles expand to half the length of the mature needles on the plant.

For formal hedges, prune the same as for informal hedges during the second year. In the third year, shear new shoots by one-half to two-thirds of their length every time they grow 6 to 12 inches. With the exception of pine species, shear conifers whenever growth elongates (it probably will be less than 6 inches long). Avoid pruning after midsummer.

Continue shearing one-half to two-thirds of the new growth during successive years until the hedge reaches the desired width. Then allow the hedge to grow more in height than width until it reaches the desired height. Do this by shearing new growth on the sides shorter (and less frequently) than the shoots on the top.

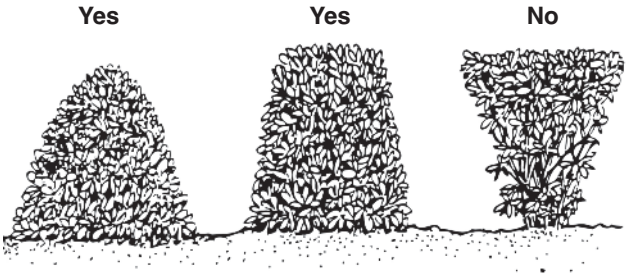


Figure 12. Trim hedges to be wider at the bottom to prevent lower branches from becoming weak and losing foliage.

Early training of vines

Train vines according to their growth habit. Vines that are natural clingers support themselves by aerial roots (e.g., English ivy). Boston ivy has small, branched tendrils tipped with adhesive disks to help it attach to a wall or structure. These vines grow on walls and other supports. Twining vines, such as honeysuckle, clematis, Virginia creeper, and wisteria, climb by curling or twining their leaf tendrils, leaf stalks, or stems on some kind of support system. Scramblers and floppers, such as roses, need to be tied to a support system.

Any required support should be in place when planting a vine. Direct (place) or train the branches of the vine in the desired directions.

Pruning mature trees and shrubs

As woody plants grow, age, and mature, they require maintenance training and pruning.

Mature deciduous and broadleaf evergreen trees

Inspect mature trees yearly, and follow with maintenance pruning if needed. On a tree neglected for many years, never remove more than one-third of the total canopy at one time. Excessive pruning can cause formation of numerous watersprouts. Watersprouts on large branches or trunks are usually weakly attached and can break off. Excessive pruning can also weaken a tree's ability to develop structural strength and good form.

Mature trees are usually large and require specific pruning knowledge and physical skills to complete the various pruning operations. For this reason, hiring a professional tree pruning company that is insured and bonded may be the best and safest way to be sure mature trees are pruned correctly.

Names for pruning operations on mature trees can vary, but the reasons for pruning remain the same as for any tree. Four typical pruning operations for mature trees are described below.

Cleaning out. This procedure primarily involves removing broken, diseased, dying, or dead branches, as well as those that cross, are weakly attached (including watersprouts and suckers), or of low vigor. These types of branches are removed from trees neglected for years. After these branches are removed, examine the tree for problems that negatively affect its growth (radial spacing of limbs) or structural strength (angle of branch attachment as well as vertical and radial spacing of limbs).

Raising the crown. This procedure involves removing lower branches from the trunk or lower parts of a tree. As a tree grows, the branch weight increases, causing limbs to bend downward. When training young trees, plan the height of the lowest scaffold branch so that removing large branches will be unnecessary, as such pruning can cause large pruning wounds. If you must remove many lower branches, do so over several years. Leave at least two-thirds of the total canopy volume on the tree.

Crown thinning. This operation involves opening up the tree canopy to permit air movement and deeper light penetration. This procedure will benefit inner leaves and branches. The first branches removed are those described in "Cleaning out" (above). For scaffold branches too closely spaced vertically or radially, remove the entire branch at its point of attachment to the main trunk.

Make cuts for crown thinning at the top and around the edges of the canopy. In most cases, choose branches 1 to 2 inches in diameter for removal, and make thinning cuts at the point of origin or to a vigorous smaller branch that is at least one-third the size of the branch being removed (drop-crotch pruning). These two types of thinning cuts should avoid inducing growth of numerous watersprouts, as long as less than one-third of the total canopy volume is removed.

Crown reduction. This procedure is used to reduce the overall size of a tree canopy when it becomes larger than is desirable or safe. Although pruning can roughly control tree size, crown reduction will need to be a regular maintenance task if the tree grows too large for its allotted space. For better effectiveness of crown reduction pruning, prune the tree just as it attains its acceptable size. Delaying pruning until the tree reaches its maximum height makes maintaining an acceptable canopy size more difficult, creates larger pruning wounds, and can induce weakly attached shoots to form.

Crown reduction involves drop-crotch pruning (described above and on page 11; also see figure 7, page 12). Properly used, drop-crotch pruning should prevent watersprouts from forming near the pruning cuts. Drop-crotch pruning can reduce tree height by one-fourth to one-third of its original size. Using thinning cuts during crown reduction will cause the plant to grow back to a critical height more slowly than topping a tree. Thinning cuts also help the tree retain its natural shape and minimize decay problems. Since

this pruning procedure involves cutting some of the most distant branches on a tree, use of a tree pruning professional should be strongly considered.

Mature deciduous and broadleaf evergreen shrubs

The unique characteristics of each type of shrub determine the pruning technique(s) used. Shrubs that produce little, if any, new growth (sprouts) from their bases, such as large viburnums and magnolias, are pruned as if they were small trees, i.e., they are trained to have scaffold branches.

When growing shrubs for flowers or fruit, plants should be pruned to encourage or enhance flower production, which should also increase fruit production. Keep in mind that removing flowers will decrease fruit production. These large shrubs (like trees) produce flowers and fruit at the tips of their branches.

With any shrub, as with trees, keep the natural form in mind and prune to develop this form by removing stems and branches that detract from the desired shape of the plant. The growth habit of the plant should be enhanced by the pruning.

Observe where the flowers are produced on a shrub in order to know how to prune it. See the listing at right for flowering locations on selected shrubs. These shrubs also produce new wood (sprouts) from stems at or near the ground level throughout their lives (continuous basal growth). These plants and similar species should be pruned as follows.

- Prune plants that flower on the mid-portions of their stems to maximize production of 2- to 5-year-old wood. Do this by removing one-fourth to one-sixth of the oldest stems at or near the ground each year. Make thinning and heading cuts on the remaining stems as necessary.
- Prune plants that flower at the tips of their stems to maximize production of terminal tips. Do this by removing a few older canes and spindly new canes at or near ground level. Head back vigorous canes to force branching and growth of new tips where desired, and thin other stems as needed.
- Thinning cuts on deciduous and broadleaf evergreen shrubs preserve the shrub's natural form. Direct growth by thinning out (removing) stems back to a vigorous side branch that points in the desired direction. Use thinning cuts to remove selected inner branches to open up a dense shrub and to maintain the size (width and height) of the shrub.
- Heading cuts on deciduous and broadleaf evergreen shrubs stimulate the development of shoots right below the cut, resulting in denser growth. Make cuts where you want branching. Use heading cuts sparingly unless you are shearing a formal hedge, topiary, or other atypical shape. Heading cuts may result in an undesirable bushy or topped look.
- See page 12 for information on when to prune flowering shrubs.

Flowering locations for selected shrubs

Plants flowering on midportions of stems
Barberry (*Berberis* spp.)
Beautybush (*Kolkwitzia amabilis*)
Brooms (*Cytisus*, *Genista* spp.)
Cotoneaster spp.
Flowering quince (*Chaenomeles* spp.)
Forsythia spp.
Holly (*Ilex* spp.)
Honeysuckle (*Lonicera* spp.)
Kerria japonica
Mockorange (*Philadelphus* spp.)

Plants flowering on terminal tips
Azaleas, evergreen (*Rhododendron* spp.)
Dogwoods, shrubby (*Cornus* spp.)
Hydrangea spp.
Lilac (*Syringa* spp.)
Magnolia spp., shrubby
Oregon grape (*Mahonia* spp., also known as *Berberis* spp.)
Photinia spp.
Potentilla fruticosa
Privet (*Ligustrum* spp.)
Rhododendron spp. (and deciduous azaleas)
Serviceberry (*Amelanchier* spp.)
Spiraea x *bumalda* cultivars
Viburnum spp.

Carefully observe where flowers are produced on species not listed.

Mature coniferous trees and shrubs

Mature conifers need little pruning if they have been cared for over time. Selected branches may be growing out of place. If so, use thinning cuts to remove them. Like deciduous trees, coniferous trees should not be topped.

The type of pruning cut to use depends on the pruning objectives. If a plant is too tall or has branches that are blocking a view or use of a structure (for example, a sidewalk), use thinning cuts to remove branches at their point of origin. Thinning cuts are often less noticeable and create an open, natural-looking plant.

On fir, spruce, and Douglas-fir, dormant buds are found mainly on branches that are 1 year old. Prune these species only into 1-year-old branches or to where you can see buds on the branch (figure 13). Pruning stems back into branch tissues that are more than 1 year old will leave permanent stubs, as the pruned branches will not produce new growth. Likewise, prune arborvitae and false-cypress plants back only to where green foliage is seen on the plants; avoid pruning back to bare branches on these species.

Conifers with latent buds, such as yew and hemlock, can be pruned severely because latent buds will grow after pruning. They will respond to heading cuts on older branches or trunks by producing strong, new foliage growth. Shearing is a type of heading cut that consists of cutting off small branches to produce an even shape. Shearing shapes plants and increases branch density. However, shearing without some thinning can cause the center of a coniferous plant to die from lack of light, thereby increasing dead zones, or areas that lack foliage.

On many conifers such as pines and junipers, latent buds are usually absent from the branches, including the current season's growth. Avoid cutting branches more than 1 year old on these species. Heading cuts that remove large amounts of foliage will result in dead zones and stubs. Pines have buds only at the tips of branches. Therefore, new growth on pines can be pruned only as the new candles expand (figure 14). This pruning will induce new buds to form at the cut surface of the stem (at the base of the needle bundles) and will make the plant more dense and shorten its height. The amount of candle to prune off depends on how much new growth is desired. If only light pruning is needed on the new growth, remove only about 1 inch of the candle. In contrast, if little new growth is desired (to keep the plant dense), remove about two-thirds of the new candle.



Figure 13. Buds (arrows) present on the newest (1-year-old) branches on a spruce tree. Photo by Robert Tripepi.



Figure 14. New growth on a pine candle (the expanding pine branch) should be pruned when new needles on the candle are about one-half the length of mature needles to induce new buds to form at the base of the needle bundles near the cut. Arrows show the buds that were induced to form. Photo by Robert Tripepi.

Damaged trees

Over time, plants may become damaged, or parts of a plant may become diseased. Physical damage often requires corrective pruning. On some species,

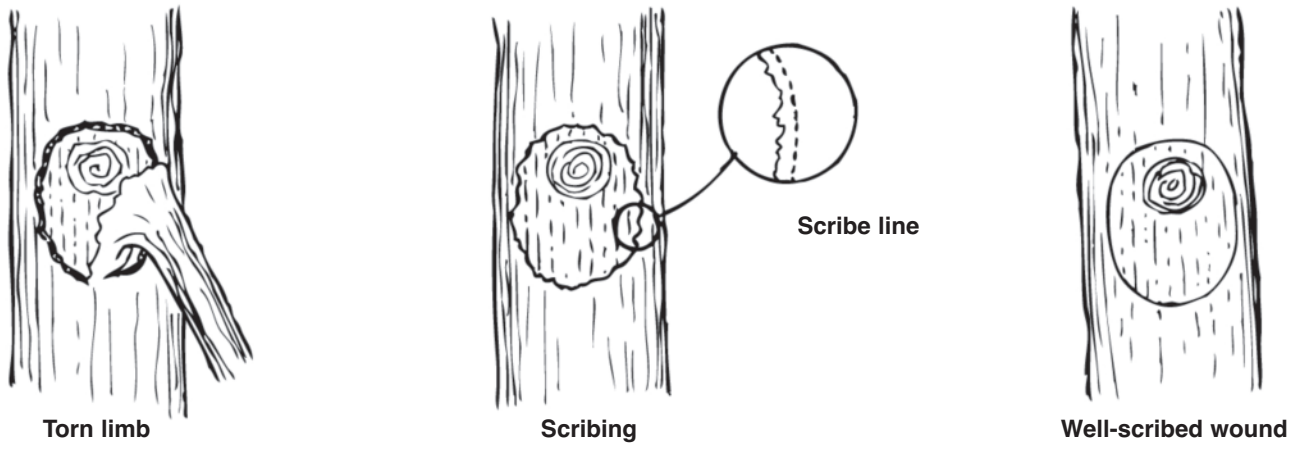


Figure 15. Remove the ragged edges of damaged tissue on broken or torn limbs. Use a chisel or sharp knife to remove the dead or dying plant tissues. Source: Colt, W. M., R. R. Tripepi, R. L. Mahoney. 1999. *How to Prune Deciduous Landscape Trees*. Bulletin 819. University of Idaho Extension, Moscow.



Figure 16. Select a new leader on a top-damaged conifer and tie it to a vertically secured stake (left). In the photo on the right, a new leader (indicated by the arrow) formed without being staked. Note the bow in the new leader. Photo by Marla Schwartz.

such as oak, branches die of natural causes and may remain attached high above the ground. Remove broken or dead branches, typically with a thinning cut, observing all of the pruning techniques outlined earlier. Sometimes, to maintain good symmetry, you can also thin or remove limbs opposite the broken ones.

After removing a broken branch that tears the bark on the branch or trunk from which it arose, carefully use a wood chisel to remove any torn or stripped bark and remove ragged edges of dead or dying bark (figure 15). Remove loose or dead bark back to where it attaches to the tree. Keep the wound as narrow as possible to hasten wound closure.

If a pyramidal conifer loses the top of its main leader (trunk), help a branch near the wounded area to become the new leader. Select the best limb, which could be the longest one, and carefully bend it upright. Tie this branch to an upright pole or stake and fasten the stake securely to the trunk (figure 16). Check ties frequently to make sure they do not cut or wound the bark, and remove the pole in 2 or 3 years.

A plant struck by lightning may not be damaged severely; remove broken branches, but do nothing else for 6 to 12 months. This length of time may be needed for damage to become visible. If damaged, the tree will decline due to an injured root system, vascular system, or cambium layer.

A hazard shrub or tree has a structural defect that may cause the plant, or a portion of the plant, to fall

on someone or something. Hazardous conditions on plants need immediate attention in order to protect lives and property. Be sure to call a certified professional arborist if you suspect you are dealing with a hazard tree.

Careful inspection and a rational assessment of problems determine what corrective measure to take. If the entire tree is dead or dying, remove it. All dead branches are accidents waiting to happen. Remove them. Prune off weak or wounded spots on branches caused by rubbing. Forked (or codominant) trunks may indicate a weak-structured tree. A sudden lean in the entire tree is cause for action. Sudden dieback of top limbs may indicate root problems. Check for signs of internal decay by examining the plant for fruiting bodies of fungi (conks) or disfiguration (cankers). Conks at the base of the tree can indicate root and trunk decay.

A tree that has been topped has an increased risk of internal decay due to the large, open wounds that may have failed to be covered by new growth before wood-rotting microorganisms entered the wounds. Examine these cut areas carefully, possibly using an increment borer or an electric drill equipped with a 1/8-inch bit, to test for soundness of branches and trunks. Keep in mind, however, that drilling or boring into a trunk causes a wound that could be detrimental to a weakened tree. If you have inherited an older tree with poor shape or structure, or one previously topped, do remedial pruning following the guidelines on page 18.

Hedges

After the second year, and in established hedges, make judicious heading cuts interspersed with a few well located thinning cuts to create the desired shape and size. Thinning cuts are typically used on informal hedges, whereas shearing is used to provide a formal shape. Thinning cuts and/or heading cuts are usually made on relatively small limbs.

Complete maintenance pruning from late winter to early spring for maximum growth. To stunt plant growth, prune in summer after the plants have completed their growth flush. Remove an occasional branch at any time.

Prune all established, full-grown formal hedges once a year after the season's growth ends, typically mid- to late summer. If you want a very formal effect, you will need to shear more often during the growing season. For a looser, less formal effect, shear only once in midsummer.

At each shearing, remove new growth to within ½ inch of the previous shearing, leaving only one to three new leaves and buds. Keep in mind that this amount of shearing will most likely result in thick, densely packed branches.

Vines

Treat vines the same as shrubs. Determine how to prune them by when (and thereby where) the flowers are produced (see listings on pages 13 and 19). Besides encouraging flowering, fruiting, and new growth, prune vines to remove weak or diseased branches. Prune any vine with a permanent framework as you would a tree.

Woody ground covers

Low-growing woody shrubs and vines often serve as ground covers. Prune these plants as though they were flowering or nonflowering deciduous, broadleaf evergreen, or coniferous evergreen shrubs.

Renovation and rejuvenation pruning

Removal of large numbers of branches may be needed on older woody plants that have become too large, have grown into obstructions, were pruned incorrectly, have little flowering wood, lack vigor, or are unattractive. Renovation may also be necessary for plants that have died back from winter kill or other damage. Remember to remove any plant that is too large for its growing space when correctly trained. Replace it with a plant of a more appropriate mature size.

If a tree was poorly placed and is now growing into an obstruction, such as overhead power lines, consider removing it and replacing it with a properly placed or smaller tree. Trees properly pruned under or beside obstructions can continue to grow. Selectively remove branches to direct growth away from wires or other obstructions. This type of pruning is called directional pruning and can result in a V-shaped or one-sided tree (figure 17). However, directional pruning is a better alternative than topping trees, since topped trees will eventually grow back into the obstruction.

Because of the danger of electrocution, if pruning will be done near a power line, be sure to contact your power company or hire a professional arborist. Only a person certified to prune near power lines can legally prune any branches growing within

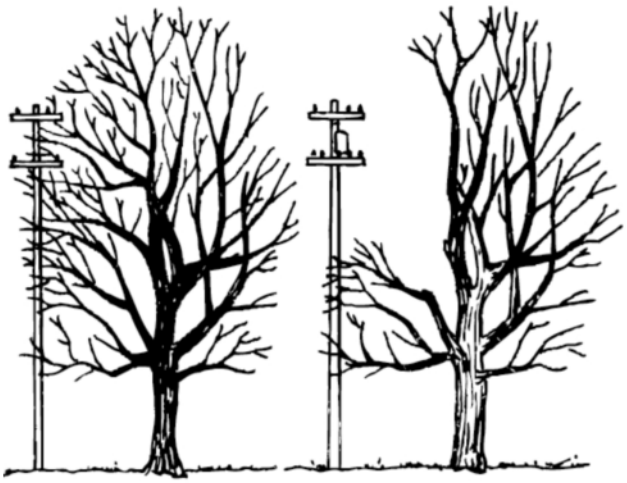


Figure 17. Side pruning was used to change the direction of this tree's growth. Source: Colt, W. M., R. R. Tripepi, R. L. Mahoney. 1999. *How to Prune Deciduous Landscape Trees.* Bulletin 819. University of Idaho Extension, Moscow.

10 feet (about 3 meters) of an energized conductor or transmission line.

Deciduous and broadleaf evergreen trees and shrubs

If a tree has never been pruned and is seriously tangled and perhaps damaged, approach pruning from the standpoint of "better late than never." In addition to the information in this section, follow the guidelines for pruning deciduous and broadleaf evergreen trees on page 18.

First, remove all dead and damaged branches, rubbing branches, branches growing inward on the tree, and branches growing outside of the natural shape of the tree. Often pruning these types of branches first clears out the canopy and is all that is necessary. Once this unwanted growth is removed, you can determine whether additional pruning is needed. The next set of branches to remove could include those with weak angles of attachment and those with inadequate vertical and radial spacing, particularly for scaffold branches. The age and condition of the tree may eliminate some pruning possibilities; for example, establishing a central leader or eliminating codominant branches may be quite difficult without severely weakening the tree.

You can use drop-crotch pruning (see page 11) to reduce the size of a tree without weakening its structure or creating an eyesore. This type of cut retains a lateral branch large enough to become the new leader. Its presence reduces latent bud sprouting and the bushy growth typical of heading cuts or topping. This method is often used by utility companies when trees grow into power lines.

Trees that have been topped or otherwise incorrectly pruned to a new height can sometimes be reshaped using thinning cuts and recommended training techniques. To correct problems from topping, remove some of the competing new branches near the pruning cut to reduce their density. Remove the tree if substantial amounts of wood rot are found, if the tree is in poor health, or if it is impossible to reconstruct a decent shape. Replace it with a recommended species for the site and space.

Deciduous and broadleaf evergreen shrubs that continuously produce basal growth can be rejuvenated by heading back all stems to 3- to 5-inch stubs. Use this technique only on shrubs that contain many latent buds. Boxwood, American holly, and almost all rhododendrons have good buds back to 3- to 5-year-old wood. Prune these severely. Cut back to 2- to 3-year-old wood on other species. This severe heading should be completed in late winter or early spring.

Once new, vigorous stems have grown about a foot long, selectively thin to remove weak or poorly placed stems and excessive growth. This step is very important for producing an attractive, healthy shrub. For shrubs with permanent scaffold branches, rejuvenate by thinning and heading back to the basic framework of the shrub.

Coniferous trees and shrubs

Rejuvenating misshapen, broken, or diseased coniferous shrubs is possible only if the plant has good latent buds on older wood. Severe heading cuts into old branches will produce vigorous growth and much smaller shrubs only if latent buds are present. Later, be sure to thin new growth to create a desirable open form (unless the plant is a sheared hedge or topiary). Complete this type of pruning in late winter or early spring before new growth begins.

Avoid rejuvenation pruning for most species of coniferous shrubs since most lack latent buds on older branches. Growing points on most species of juniper, arborvitae, and false-cypress are found only in green foliage on young twigs. Severe heading cuts to stems of these species usually results in branch stubs without new foliage or needles. Some

exceptions exist; for instance, one species of arborvitae has latent buds on older stems, and at least one species of juniper has a few latent buds. The bottom line, however, is that rejuvenation pruning is not practical for most species of pine, spruce, fir, juniper, arborvitae, false-cypress, and other conifers that lack latent buds on older stems and trunks. To correct damage or remove dead branches on most conifer species, make the necessary corrective thinning cuts and then prune new, young growth to increase foliage density.

PROTECTING TREES AND SHRUBS DURING CONSTRUCTION

Older trees contribute to the diversity of the landscape and should be preserved during construction if at all possible. Remove trees that are in poor health, those unable to withstand the necessary changes in their environment (such as shade lovers suddenly exposed to full sun), those leaning over an existing or proposed structure, and those that will be 5 feet or closer to a constructed building or utility line.

Good preconstruction planning often can ensure the survival of desirable trees. For instance, installing a flagstone walk or permeable pavers over a root system, rather than concrete or asphalt, allows aeration and water penetration to tree roots. Work with contractors to designate areas for driving, parking, and materials storage. Stake out exact locations of trenches. If plants cannot remain where they are currently growing, consider transplanting any that are small enough or that can be dug with a tree spade.

Soil compaction seriously limits aeration and water penetration to root systems. The best solution is to keep all heavy equipment and foot traffic off of root zones. First, surround trees with a barrier that extends beyond the dripline. This barrier will keep heavy equipment from driving over the majority of the plants' roots and from causing physical damage by running into trees. The barrier will also keep chemical spills away from the root system.

If equipment or people must travel over a tree's root system, spread about 6 inches of wood chips or bark mulch (the larger the chip size the better). To provide even more protection, cover root areas with steel bridges, mesh matting, exterior plywood, or planks on top of the mulch. Use of mulch or wood chips and metal or plywood sheets will reduce compaction by spreading out the weight of heavy equipment or foot traffic.

Severing roots can be very damaging to trees, reducing their water- and nutrient-absorbing capacities and sometimes affecting their stability in the soil. Careful selection of routes for underground utilities—detouring around root systems when possible—can reduce damage to roots. If rerouting trenches for utility lines is impossible, tunneling, rather than trenching, is a good solution. To reduce damage to trees close to structures, substitute posts and pillars for footers and walls that require a trench.

Changes in grade can be extremely destructive to shrub and tree root systems, since cutting (removing soil) severs roots, whereas filling (adding soil) usually buries roots, causing them to die due to lack of oxygen. Avoid grade changes by using retaining walls to maintain the original soil level over the majority of the root zone. Also, tree wells or tree islands can help maintain the original grade and minimize cutting of roots. Make wells or islands as large as possible. When a grade is changed more than 6 inches, vertical mulching (see page 6) may help modify the effect of extra soil.

WOODY LANDSCAPE PLANTS FOR IDAHO

Given the hundreds of plant species, botanical varieties, and cultivars that can be grown in the Intermountain West, selecting the right trees, shrubs, vines, and ground covers for your landscape can be an enormous challenge.

A limited selection of woody plants suitable for Idaho is provided in this chapter (see table 1, page 26); however, many other plant species and cultivars are available. Table 1 provides categories that can be used in selecting plants for different purposes and growing conditions. Consult the Internet, CD-ROM disks, resource books, local garden centers, landscape architects, your extension educator, and "Further Reading and Resources" in this chapter. Use plant descriptions and photos to visualize what will best meet your own and your site's needs and preferences. Then, make a list and seek quality plants from the best sources. Be open to using alternative plants.

In southern Idaho, summer temperatures and light intensity are high and humidity is low. Northern Idaho has higher humidity and frequent cloud cover. Summer temperatures in southern Idaho can exceed

100°F, while northern Idaho experiences cooler temperatures (80° to 90°F). During the winter, dormant conditions, elevation, local microclimates, and temperature determine plant survival.

Plants listed in garden publications from the eastern United States and lower coastal elevations often do poorly in Idaho for several reasons: early or late frosts, different soil characteristics, the dry summer climate, etc. For these reasons, plants native to Idaho and the Intermountain West often grow best in many regions of the state. More and more native plants are becoming available at retail garden stores. Use the Internet or consult with local garden stores to learn about native plants that will thrive in your area.

Table 1 lists some of the top woody landscape plants for Idaho. These plants have grown well or are deemed worthwhile for trial in Idaho. Selections were made based on Idaho research and recommendations from Idaho horticultural professionals, arborist associations, tree committees, urban foresters, and the Idaho nursery industry. This list provides selected plants from a large number of woody species, varieties, and cultivars.

The following attributes are listed for the plants:

- Common name: The most widely accepted common name is given.
- Scientific name: Since several plants may share the same common name, the scientific name is included for precise identification.
- Desirable cultivars (cultivated varieties) are listed.
- Height: Mature height varies, depending on the region of the state, microclimate, fertilizer practices, light source and intensity, and soil conditions. A range of heights is given for most woody landscape plants listed.
- Bloom time: Approximate time of flowering.
- Color: Refers to foliage color. Color for listed cultivars may vary.
- Light: Categorizes the plant into one or more light regimes: full sun is uninterrupted sunlight through the full day; partial sun is filtered sunlight through tree leaves or a minimum of 6 to 8 hours of sunlight per day; full shade indicates filtered sunlight through a dense foliage canopy or less than 6 hours of sunlight each day.
- Use in landscape: Lists potential planting locations as well as functions; for example, street tree, Xeriscape™, windbreak, or native. This category also indicates whether irrigation is critical.
- USDA zone: These ratings are based on the USDA plant hardiness zones for Idaho (see Figure 1, chapter 16, page 16-3) and upon reported preferences by region by Idaho plant professionals. Keep in mind that factors other than low temperatures affect plant survival in a specific area, and USDA zones should be used only as a guideline.
- Idaho zone: Indicates in which part of Idaho this plant will grow best.
- Growth habit: Provides a mental picture of the mature form or outline of the plant.
- Rate of growth: Refers to the vertical increase in growth unless specified differently. The designation "slow" means the plant grows 12 inches or less per year, "medium" indicates 13 to 24 inches of growth per year, and "fast" is 25 inches or more of new growth in 1 year. Rate is influenced by numerous variables such as soil, drainage, water, light, and exposure.
- Wildlife rating: Provides a guideline of the likelihood that the plant will attract and be damaged by wildlife.
- Utility rating: When available, this rating indicates whether this plant may be planted under power lines.
- Source: Reference that lists this plant.

Table 1. Woody plants for Idaho landscapes.

The following key is used in this table:

Height: At maturity with a range for most plants (spread for vines)

Bloom: Season of flowering
- Sp = spring
- Su = summer
- F = fall

Color: Predominant foliage color
- Grn = green
- Pur = purple
- Yell = yellow
- Gry = gray
- Blu = blue
- Wht = white

Light:
- F = full sun
- P = part sun
- S = shade

Use in landscape:
- B = border
- S = specimen
- W = windbreak
- St = street tree
- X = Xeriscape™
- I = irrigation
- N = native

USDA zone: Idaho has USDA plant hardiness zones 3 through 6.

Idaho zone:
- 1 = northern Idaho
- 2 = southwestern Idaho
- 3 = eastern Idaho
- All = whole state

Growth habit:
- P = pyramidal
- V = vase shaped
- W = weeping
- R = round
- U = upright
- C = columnar
- G = globe
- O = oval
- M = mound
- F = feathery
- S = spreading

Rate:
- F = fast growth
- M = medium growth
- S = slow growth

Wildlife rating:
- 1 = Protective—Rare damage
- 2 = Protective—Slight damage
- 3 = Beneficial—Some damage
- 4 = Attractive—Severe damage

Utility rating:
- _ = Recommended for planting under powerlines
- ? = Questionable for planting under powerlines
- Ø = Not recommended under powerlines
- $ = Extreme expense; NOT recommended under powerlines.
- * = Not a concern under powerlines

Source: The referenced sources that list these plants as growing in our region.

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Large deciduous trees—over 50 feet													
Ash, green	*Fraxinus pennsylvanica* 'Bergeson' 'Marshall' 'Patmore' 'Urbanite'	50–60'	—	Grn	F	S,W,X	3–6	All	U,S	M	1	Ø	1,2,6
Ash, Raymond	*Fraxinus oxycarpa* 'Raywood'	40–50'	—	Grn	F	S	5–6	1,2	O,U	M	1	Ø	2
Ash, white	*Fraxinus americana* 'Autumn Applause' 'Autumn Purple' 'Rosehill' 'Skyline'	50–60'	—	Grn	F	St	4–6	All	O,U	M	1	Ø	1,2
Aspen, quaking	*Populus tremuloides*	30–50'	—	Grn/Gry	F,P	S,I	3	All	S,U	F	2	Ø	1
Baldcypress	*Taxodium distichum*	50–80'	—	Grn	F	S,I	5–6	1,2	P	M	1	$	2,4
Beech, European	*Fagus sylvatica* 'Asplenifolia' 'Pendula' 'Riversii' 'Roseo-Marginata'	50–70'	Sp	Grn/Pur	F,P	S	5–6	1,2	O,U	S	2	Ø	2,6
Birch, river	*Betula nigra* 'Heritage'	40–60'	—	Grn	P,S	S,N	4–6	All	O,U	M	2	Ø	2
Catalpa, northern	*Catalpa speciosa*	50–70'	Su	Grn	F,P	S,X	5–6	All	S,U	F	3	Ø	1
Coffeetree, Kentucky	*Gymnocladus dioicus* 'Espresso'	50–75'	Sp	Grn	F	S	4–6	1,2,3	U,O	S	4	Ø	2

Table 1 (cont). Woody plants for Idaho landscapes. (See page 26 for the key to abbreviations used in this table.)

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Corktree, amur	*Phellodendron* amurense 'Macho'	35–45'	—	Grn	F	S	4–6	All	U,V	M	2	Ø	2
Filbert, Turkish	Corylus colurna	40–50'	—	Grn	F	S,X,	5–6	1,2	P	M	2	Ø	2
Hackberry, common	*Celtis occidentalis*	40–60'	—	Grn	F	S,W,X	4–6	All	U,O	S	3	Ø	1,2
Honeylocust	*Gleditsia triacanthos* var. *inermis* 'Imperial' 'Moraine' 'Shademaster' 'Skyline'	30–60'	Sp	Yell/Grn	F	S,W,X	5–6	All	S,U	M	3	Ø	1,2,5
Hornbeam, European	*Carpinus betulus* 'Fastigiata'	40–50'	—	Grn	F,P	S,St	5–6	1,2	P,O	S	2	Ø	2
Horsechestnut	*Aesculus hippocastanum* 'Baumannii'	40–60'	Sp	Grn	F,P	S	4	All	U,O	M	3	Ø	1,2
Larch, European	*Larix decidua*	50–70'	—	Grn	F	S,W,B	3–6	All	P	M	2	$	2,4
Linden, American	*Tilia americana* 'Legend' 'Redmond'	40–60'	Su	Grn	F,P	S,I	3–6	All	P,O	M	1	Ø	2
Linden, littleleaf	*Tilia cordata* 'Chancellor' 'Corinthian' 'Glenleven' 'Greenspire'	40–60'	Su	Grn	F	S	4–6	All	P,O	S	2	Ø	1
Linden, silver	*Tilia tomentosa* 'Green Mountain' 'Sterling'	40–60'	Su	Grn/Wht	F	S	5–6	1,2	O,P	M	3	Ø	2
Locust, black	*Robinia pseudoacacia*	40–50'	Su	Grn	F	B,W,X	3	All	S,U	F	4	$	1
Maidenhair tree	*Ginkgo biloba* 'Autumn Gold' 'Magyar' 'Princeton Sentry'	40–60'	—	Grn	F	S	4–6	1,2	P,S	S	3	Ø	1,2
Magnolia, cucumbertree	*Magnolia acuminata*	40–60'	Sp	Grn	F,P	S,I	4–6	1,2	O	M	1	Ø	2
Maple, Freeman	*Acer* X *freemanii* 'Autumn Blaze'	50–60'	Sp	Grn	F,P	S	4–8	All	O	M	2	Ø	
Maple, Norway	*Acer platanoides* 'Columnare' 'Crimson King' 'Deborah' 'Emerald Queen' 'Royal Red' 'Schwedler'	40–50'	Sp	Grn	F,P	S	4–6	All	U,O	M	2	Ø	1,2
Maple, sugar	*Acer saccharum* 'Green Mountain' 'Legacy'	50–70'	—	Grn	P,S	S	4–6	1,2	O,U	S	3	Ø	2,4
Oak, bur	*Quercus macrocarpa*	70–80'	—	Grn	F	S,W,X	3–6	All	O,U	S	4	Ø	2

Table 1 (cont). Woody plants for Idaho landscapes. (See page 26 for the key to abbreviations used in this table.)

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Oak, English	*Quercus robur* 'Fastigiata'	50–70'	—	Grn	F	S	5–6	All	U,O,C,	M	4	Ø	1,2,4
Oak, northern red	*Quercus rubra*	50–75'	—	Grn	F,P	S	5–6	1,2	U,O,C	S	4	Ø	1
Oak, swamp white	*Quercus bicolor*	50–70'	—	Grn	F,P	S	4–6	All	O,U	M	4	$	2
Oak, white	*Quercus alba*	50–80'	—	Grn/Gry	F,P	S	4–6	All	U,O	S	4	Ø	1
Pagodatree, Japanese	*Sophora japonica*	40–60'	Su	Grn	F	S	5–6	1,2	O,U	M	1	Ø	2
Persimmon, common	*Diospyros virginiana*	30–50'	Sp	Grn	F	S	5–6	1,2	O	S	3	Ø	2
Planetree, London	*Platanus* x *acerifolia* Note: the scientific name is sometimes listed as *Platanus* × *hybrida* 'Bloodgood'	50–100'	—	Grn	F,P	S	4–6	1,2	O	M	3	$	1
Poplars	*Populus* spp.	50–80'	—	Grn/Gry	F,P	W,N,I	3	All	O,U,S	F	1	$	1
Poplar, black	*Populus trichocarpa*	75–100'	—	Grn	F	S,N,I	4–6	All	V	F	1	$	2
Poplar, white	*Populus alba* 'Bolleana'	45–90'	—	Grn/Wht	F,P	S,B	3–6	All	U,S	F	1	$	1
Sweetgum	*Liquidambar styraciflua*	50–60'	—	Grn	F	S,I	5–6	1,2	P,O	M	2	Ø	1,2
Tree-of-Heaven	*Ailanthus altissima*	30–45'	—	Grn	F	S	4	All	U,S	F	4	Ø	1
Tuliptree	*Liriodendron tulipifera*	65–90'	Sp	Grn	F	S,I	5–6	1,2	U,O	M	3	$	1
Walnut, black	*Juglans nigra*	40–50'	—	Grn/Yell	F	S,W	4	All	U,D	M	3	$	1
Willow	*Salix* spp. 'Tristis' golden weeping 'Tortusa' corkscrew	40–80'	—	Grn/Yell	F,P	S,I,N	3	All	U,S,O	F	4	$	1
Yellowwood	*Cladrastis kentukea*	30–50'	Sp	Grn	F,P	S,I	5–6	1,2	O	M	1	Ø	2
Large evergreen trees—over 50 feet													
Arborvitae, eastern	*Thuja occidentalis* 'Pyramidalis'	30–50'	—	Grn	F	B,S	3–6	All	P	M	2	$	2,4
Douglas–fir	*Pseudotsuga* menziesii	40–60'	—	Grn	F,P	S,N	4–6	All	P	M	1	$	2,4
Fir, subalpine	*Abies lasiocarpa*	40–50'	—	Blu/Grn	P	S,I,N	3–6	All	U,C,P	S	2	$	1
Fir, white	*Abies concolor*	50–70'	—	Gry/Grn	F,P	S,N	4–6	All	P,U	M	2	$	2,4
Pine, Austrian	*Pinus nigra* var. *nigra*	50–60'	—	Grn	F	S,W	4–6	All	U,P	M	3	$	1,2
Pine, ponderosa	*Pinus ponderosa*	50–100'	—	Grn	F	S,W, N,B	4–6	All	U,P	M	2	$	1,2,4,5
Pine, Scots	*Pinus sylvestris*	50–80'	—	Grn	F	S,W,B, St	3–6	All	U,P	M	1	$	1,2,4
Pine, Swiss stone	*Pinus cembra*	30–40'	—	Grn	F	S	4–6	All	P,C	S	2	Ø	3,4
Spruce, Colorado	*Picea pungens*	45–80'	—	Grn/Gry	F	S,W	3–6	All	U,P	S	2	$	1,2,4
Spruce, Engelmann	*Picea engelmannii*	80–100'	—	Grn	F	S,B	3	All	U,P	S	1	$	1,2,4
Spruce, Norway	*Picea abies*	50–70'	—	Grn	F	S,B	4–6	All	U,P	M/F	2	$	1,2,4
Spruce, Serbian	*Picea omorika*	50–60'	—	Grn/Gry	F,P	S,B	4–6	All	P,C	S	2	$	2,4
Spruce, white	*Picea glauca*	40–50'	—	Grn	F,P	S,W	3–6	All	P	M	2	$	2,4

Table 1 (cont). Woody plants for Idaho landscapes. (See page 26 for the key to abbreviations used in this table.)

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Medium deciduous trees—25 to 50 feet													
Alder, mountain	*Alnus tenuifolia*	20–40'	Sp	Grn	F,P	S,N,I	3–6	All	O	M	2	Ø	2
Apricot	*Prunus armeniaca*	15–25'	Sp	Grn	F	B	4	All	S,O	M	4	?	1
Cherry plum	*Prunus cerasifera* 'Atropurpurea' 'Newport' 'Thundercloud'	15–25'	Sp	Pur	F	S,B,St	4–6	1,2	U,O	M	3	—	1
Cherry, Japanese flowering	*Prunus serrulata* 'Kwanzan' 'Mount Fuji'	20–25'	Sp	Grn	F	S,St,I	5–6	1,2	S,C,V	F	3	—	2,3
Chokecherry	*Prunus virginiana* 'Shubert'	15–30'	Sp	Grn	F	B,W	2–6	All	S,O	M	3	—	
Crabapple	*Malus* spp. 'Adirondack' 'Donald Wyman' 'Indian Summer' 'Prairifire' 'Purple Prince' 'Red Jewel' 'Spring Snow' 'Strawberry Parfait'	15–40'	Sp	Grn/Red	F,P	St	3–6	All	S,U,C,O	F	4	?	1,2,3,4
Dogwood, flowering	*Cornus florida*	20–25'	Sp	Grn	P	B,S	5–6	1,2	R,U	S	2	?	2,3
Dogwood, Kousa	*Cornus kousa*	15–25'	Sp	Grn	P	B,S	5–6	1,2	R,U	S	2	?	2
Dogwood, Cornelian cherry	*Cornus mas*	20–25'	Sp	Grn	F	B,S,St	4–6	All	O	M	3	?	3
Eastern redbud	*Cercis canadensis*	20–30'	Sp	Red/Grn	F,P	S,I	5–6	1,2	O	M	2	?	2,3
Filbert, purple giant	*Corylus maxima* var. *purpurea*	15–20'	Sp	Pur	P	B	5–6	1,2	R,P	S	3	?	3,4
Goldenrain tree	*Koelreuteria paniculata*	30–40'	Su	Grn	F	S,X	5–6	1,2	O	F	1	Ø	2
Hawthorn, English	*Crataegus laevigata*	15–24'	Sp	Grn	F,P	St	3–6	All	S,U,C,O	M	3	?	1,2
Hawthorn, green	*Crataegus viridis*	25–35'	Sp	Grn	F	St,S,B	5–6	1,2	O	M	3	?	2,3
Hawthorn, Lavalle	*Crataegus* × *lavallei*	15–30'	Sp	Grn	F	B	4–6	1,2	O	M	2	?	1,2,4
Hawthorn, Washington	*Crataegus phaenopryum*	20–30'	Sp	Grn	F	St,S,B	3–6	All	O	M	3	?	1,2,3
Hornbeam, columnar	*Carpinus betulus* 'Columnaris'	20–40'	—	Grn	F	B,S,St	4–6	All	U,P	M	2	Ø	3
Lilac, Japanese tree	*Syringa reticulata*	20–30'	Sp	Grn	F	S,St	4–6	1,2	O	M	1	?	2
Magnolia, saucer	*Magnolia* × *soulangiana*	20–30'	Sp	Grn	F,P	S,I	5–6	1,2	P,O	M	1	?	2
Maple, amur	*Acer ginnala*	15–20'	Sp	Grn	F,P	B,WB, S	3–6	All	U,S	M	2	—	1,2,3
Maple, hedge	*Acer campestre*	25–35'	—	Grn	F,P	St,S	5–6	1,2	O	S	2	?	2
Mountain ash, American	*Sorbus americana*	10–30'	Sp	Grn	F	B,S	3–6	All	R,U,S	F	3	Ø	4
Mountain ash, European	*Sorbus aucuparia*	25–50'	Sp	Grn	P	S	4–6	All	R,U,S	M	3	Ø	1

Table 1 (cont). Woody plants for Idaho landscapes. (See page 26 for the key to abbreviations used in this table.)

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Olive, Russian	*Elaegnus angustifolia*	20–45'	Sp	Gry	F	S,W,X	4	All	U,S,O	M	4	$	1,5
Pear, Callery	*Pyrus calleryana* 'Aristocrat' 'Redspire'	25–35'	Sp	Grn	F	St,S	5–6	1,2	O,P	M	1	?	2
Plum, Blireiana	*Prunus* × *blireiana*	15–25'	Sp	Red/Pur	F	S	5–6	1,2	O	M	3	?	2
Serviceberry	*Amelanchier* × *grandiflora*	20–25'	Sp	Grn	F	B	4–6	All	U,O	M	4	—	3
Walnut, Persian	*Juglans regia*	40–50'	Sp	Grn	F	S	5–6	All	U,O	S	4	Ø	1
Medium evergreen trees—25 to 50 feet													
Juniper, Rocky Mountain	*Juniperus scopulorum*	20–40'	—	Gry/Grn	F	B,W,B,N	3–6	All	P,O	S	2	?	1,2,3
Juniper, Utah	*Juniperus osteosperma*	20–40'	—	Gry/Grn	F	B,W,B,N	3	All	S,U	S	2	1	—
Pine, limber	*Pinus flexilis*	20–50'	—	Grn	P	S,N	3–6	All	P	S	1	Ø	1,2,4
Redcedar, eastern	*Juniperus virginiana*	20–40'	—	Grn/Red	F	B	4	1,2	G,U	S	2	?	1,2,3
Small deciduous trees—under 25 feet													
Fringe tree, Chinese	*Chionanthus retusus*	8–20'	Sp	Grn	F,P	S,B,St	5–6	1,2	O	M	2	—	3,4
Gamble oak	*Quercus gambelii*	5–15'	—	Grn	F,P	S,	4–6	All	S,U	S	4	—	5
Goldenchain tree	*Laburnum* × *watereri*	12–15'	Sp	Grn	F,P	B,S,St	5–7	1,2	O,R	M	2	?	3,4
Magnolia, star	*Magnolia stellata*	15–20'	Sp	Grn	F,P	S,I	4–6	1,2	S,O	M	1	?	2,3
Sumac, smooth	*Rhus glabra*	10–15'		Grn	F	B,S,N,X	3	All	S,W	F	3	—	1
Sumac, staghorn	*Rhus typhina*	15–25'	Su	Grn	F	B,S,X	3–6	All	S	F	3	—	2,3,5
Small evergreen trees—under 25 feet													
Arborvitae	*Thuja occidentalis* 'Globosa' 'Little Gem'	15–25'	—	Grn	F,P	B	4	All	C,G,U	M	2	?	1
Pine, bristlecone	*Pinus aristata*	8–20'	—	Grn	F	S,B,I	4–6	All	P	S	1	?	1,2,3,4
Pine, mugo	*Pinus mugo* 'Mugo'	15–25'	—	Grn	F	B,I	3–6	All	S,U	S	2	?	2,4,5
Yew, Hicks	*Taxus* × *media* 'Hicksii'	10–15'	—	Grn	F,P,S	B,I	4–6	1,2	C,O	F	2	?	3,4
Large shrubs—over 8 feet													
Cherry, Nanking	*Prunus tomentosa*	6–8'	Sp	Grn	F,P	B,W	3–6	All	P,M	F	3	?	5
Chokeberry, black	*Aronia melanocarpa*	10–15'	Sp	Grn	F	B,S	4–6	All	G,M	M	4	?	4
Chokeberry, purple fruited	*Aronia prunifolia*	10–15'	Sp	Grn	F	B,S	4–6	All	G,P	M	3	?	4
Cranberrybush, American	*Viburnum trilobum*	10–15'	Sp	Grn	F	B	2–7	All	G	F	4	?	3,4
Firethorn	*Pyracantha coccinea*	10–15'	Sp	Grn	F,P	B,S	5–6	All	S,P	F	3	?	5
Juniper, common	*Juniperus communis*	5–10'	—	Gry/Grn	F,P	B,N	3–6	All	S,M	M	2	?	5
Lilac, common	*Syringa vulgaris*	8–15'	Sp	Grn	F	B,W	3–7	All	P,G	M	2	?	4,5
Lilac, late	*Syringa villosa*	8–15'	Sp	Grn	F,P	B,W	3–7	All	P,G	M	2	?	—
Mockorange, Lewis'	*Philadelphus lewisii*	5–10'	Su	Grn	F,P	S,B,N	4–6	All	S,O	F	2	*	5
Peashrub, Siberian	*Cargana arborescens*	15–20'	Sp	Grn	F	B,W	2–7	All	P	F	2	?	3

Table 1 (cont). Woody plants for Idaho landscapes. (See page 26 for the key to abbreviations used in this table.)

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Serviceberry, Saskatoon	*Amelanchier alnifolia*	8–15'	Sp	Grn	F	B,S	4–6	All	P,O	F	4	?	4
Serviceberry, Shadblow	*Amelanchier canadensis*	8–15'	Sp	Grn	F,P	B,S	4–6	All	P,O	F	4	?	4
Smoke tree	*Cotinus coggyria* 'Purpureus'	10–15'	Sp	Pur/Grn	F	B,S	5–6	All	O,P	F	2	?	2,3,4
Snowball, common	*Viburnum opulus* 'Roseum'	10–15'	Sp	Grn	F,P	S,B	4–6	All	P	F	2	?	5
Snowball, fragrant	*Viburnum × carlcephalum*	8–10'	Sp	Grn	F,P	S,B	4–6	All	P	F	2	*	5
Spirea, bridalwreath	*Spiraea prunifolia*	5–10'	Sp	Grn	F	B,S	5–6	All	V	F	2	*	8
Spirea, Vanhoutte	*Spiraea × vanhouttei*	5–10'	Sp	Grn	F	B,S	4–6	All	V	F	2	*	8
Viburnum, arrowood	*Viburnum dentatum*	6–8'	Sp/Su	Grn	F,P	S,B	2–7	All	P,G	M	2	*	4
Viburnum, Siebold	*Viburnum sieboldii*	15–20'	Sp	Grn	F,P	B,S	4–6	1,2	U,O	F	4	?	3
Yew, hybrid	*Taxus × media*	4–15'	Sp	Grn	F,P,S	B	4–6	All	C	M	2	?	5
Yucca	*Yucca flaccida*	4–7'	Su	Gry/Grn	F	S	4–6	All	O	M	2	*	5
Small shrubs—3 to 5 feet													
Almond, dwarf flowering	*Prunus glandulosa*	4–6'	Sp	Grn	F,P	B	4–6	All	M,S	M	4	*	5
Almond, dwarf Russian	*Prunus tenella*	4–5'	Sp	Grn	F,P	B	2–6	All	M,S	M	4	*	4
Barberry, Japanese	*Berberis thunbergii*	3–6'	Sp	Red/Gry	F,P	S,B	4–6		P,S	M	3	*	5
Burning bush, dwarf	*Euonymus alatus* 'Compactus'	3–6'	Sp	Grn	F,P	B,S	3–6	1,2	G,P	F	3	*	4,5
Ceanothus, Fender	*Ceanothus fendleri*	1–2'	Sp	Gry/Grn	F,P	S,B,N,X	4–6	All	S,P	F	2	*	5
Cinquefoil, shrubby	*Potentilla fruticosa*	1–4'	Su	Grn	F	B	2–6	All	M	M	1	*	4
Cotoneaster, rock	*Cotoneaster horizontalis*	3–4'	Sp	Grn	F,P	B	4–6	1,2	M	F	3	*	5
Cotoneaster, cranberry	*Cotoneaster apiculatus*	3–4'	Sp	Grn	F,P	B	5–6	1,2	M	F	3	*	4,5
Currant, alpine	*Ribes alpinum*	3–5'	Sp	Grn	F,P	S,B,N	3–6	All	G,M	F	3	*	5
Dogwood, red twig	*Cornus sericea*	7–9'	Sp	Grn	F,P	B,W,N	2–6	All	S,U	F	3	—	—
Dogwood, Tatarian	*Cornus alba*	8–10'	Sp	Grn/Red	F,P	B,W	2–6	All	S,U	M		*	4
Firethorn, compact	*Pyracantha angustifolia* 'Gnome'	12–15"	Su	Grn	F	I	5–6	All	S	M	3	*	8
Juniper, Chinese	*Juniperus chinensis* 'Gold Coast' 'Mint Julep'	2–10'	—	Grn/Yell	F	B,S	4–6	All	Various	M,F	1	*	4
Oregon Grape holly	*Mahonia aquifolium* 'Compactum'	3–6'	Sp	Red/Grn	F	S,B	4–6	All	S	M	3	*	4,5
Rhodendendron, azalea	*Rhododendron* spp.	0.5–5'	Sp	Grn/Gry	P	B,S	4–6	1,2	U,M	M,S	2	*	4

Table 1 (cont). Woody plants for Idaho landscapes. (See page 26 for the key to abbreviations used in this table.)

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Sandcherry, western	*Prunus besseyi*	7–10'	—	Grn/Gry	F	B,N	2–6	All	M	M	3	*	4
Snowberry	*Symphoricarpos albus*	3–6'	Sp	Grn	F,P	N	3–6	All	U,M	M	4	*	4
Spruce, dwarf Norway	*Picea abies* 'Nidiformis' 'Procumbens'	2–4'	—	Grn/Gry	F	B,S	2–6	All	Various	S	1	*	4
Sumac, scented	*Rhus trilobata* 'Lemonade Sumac' 'Skunkbush Sumac'	3–5'	Sp	Grn	F	N,X	3–6	All	P,S	M	3	*	8
Ground covers													
Bunchberry	*Cornus canadensis*	6–9"	Sp	Grn	P,S	I,N	5–6	1,2	S	M	3	*	8
Checkerberry, mountain	*Gaultheria ovatifolia*	8"	Su	Grn	P,S	N	5–6	All	S	M	4	*	8
Cotoneaster, creeping	*Cotoneaster adpressus*	8–12"	Sp	Grn	F,P	S	4–6	All	S	M	2	*	5
Crowberry	*Vaccinium vitis-idaea*	12"	Sp	Grn	P	I	3–6	1,2	S	S	3	*	8
Germander	*Teucrium chamaedrys* var. *prostratum*	4–12"	Su	Grn	F	I	3–6	All	S	M	1	*	8
Honeysuckle, Halls	*Lonicera japonica* 'Halliana'	6–12"	Sp	Grn	S	I	3–6	All	S	F	2	*	5
Juniper, singleseed	*Juniperus squamata*	4–6"	—	Grn	F	N,X	5–6	1,2	S	M	1	*	4
Juniper, creeping	*Juniperus horizontalis* 'Bar Harbor' 'Blue Rug' (also called 'Wiltoni')	12–16"	—	Grn/Blu	F,P	S,N	3–6	All	S	M	2	*	4,5
Kinnickinnick	*Arctostaphylos uva-ursi*	4–6"	Sp	Grn	S,P	N,X	3–6	1,3	S	M	4	*	5
Mahonia	*Mahonia repens*	6–12"	Sp	Red/Grn	S,P	N,X	4–6	All	S	M	4	*	5
Paxistima, Canby	*Paxystima canbyi*	1–2'	Sp	Grn	F,P	B,N,I	4–6	All	M	M	1	*	4
Periwinkle	*Vinca minor*	4–6"	Sp	Grn	S	I	3–6	All	S	F	2	*	5
Silverwood	*Genista pilosa*	12–15"	Su	Grn	F	N	5–6	1,2	S	F	1	*	8
Sun rose	*Helianthemum nummularium*	6–8"	Su	Grn/Gry	F	X	3–6	All	S	M	1	*	8
St. Johnswort	*Hypericum calycinum*	12–18"	Su	Grn	F,S	X	5–6	All	S	F	1	*	8
Spurge, Japanese	*Pachysandra terminalis* 'Green Carpet'	6–10"	Su	Grn	P,S	I	4–6	All	S	F	1	*	8
Wintergreen, creeping	*Gaultheria procumbens*	6"	Su	Grn	P	I	3–6	1,2	S	M	4	*	8
Vines													
Akebia, fiveleaf	*Akebia quinata*	15–20'	Sp	Grn	All	I	4–6	All	S	M	2	?	8
Bittersweet	*Celastrus* spp.	10–40'	Sp	Grn	F	I	3–6	All	S	M	2	?	8
Clematis	*Clematis* spp. × *jackmanii* 'Henryi' 'Nelly Moser'	8–20'	Sp,Su,F	Grn	P	I	4–6	All	Sp	F	1	*	8
Clematis, evergreen	*Clematis armandii*	15–20'	Sp	Grn	P	I	7	1,2	Sp	F	1	*	8

Table 1 (cont). Woody plants for Idaho landscapes. (See page 26 for the key to abbreviations used in this table.)

		Height	Bloom	Color	Light	Use	USDA	Idaho	Habit	Rate	Wildlife	Utility	Source
Euonymus, wintercreeper	*Euonymus fortunei*	20–30'	Sp	Grn	F,P	I	3–6	All	S	F	2	*	8
	'Canadale Gold'												
	'Coloratus'												
	'Emerald Gaiety'												
Grape	*Vitis riparia*	10–15'	Su	Grn	P	I	3–6	All	S	F	4	*	9
Honeysuckle, Japanese	*Lonicera japonica*	10–15'	Sp	Grn	P	I	4–6	All	S	F	1	?	8
	'Aureo—reticulata'												
	'Halliana'												
	'Purpurea'												
Honeysuckle, trumpet	*Lonicera sempervirens*	10–15'	Sp	Grn	P	I	4–6	1,2	S	F		*	8
Hop	*Humulus lupulus*	15–30'	Su	Grn	F	I	3–6	All	S	F	1	?	8
Hydrangea, climbing	*Hydrangea anomala* subsp. *petiolaris*	8–15'	Sp	Grn	P	I	3–6	All	S	S	2	*	8
Ivy, Boston	*Parthenocissus tricuspidata*	20–50'	—	Grn	All	I	4–6	All	S	F	2	?	8
Ivy, English	*Hedera helix*	10–30'	—	Grn	P,S	I	4–6	All	S	F	1	?	8
	'Arborescens'												
	'Baltica'												
	'Bulgarica'												
Kiwi, hardy	*Actinidia arguta*	20–50'	Sp	Grn	F	I	4–6	All	S	F	3	*	8
	'Ananasnaja'												
	'Hood River'												
	'Issai'												
Rose	*Rosa* spp.	6–15'	Sp,Su, F	Grn	F,P	I	3–6	All	S	M	3	*	8
	'Blaze'												
	'Royal Sunset'												
	'White Dawn'												
Trumpetvine	*Campsis radicans*	10–40'	Sp	Grn	F,P	I	4–6	All	S	F	1	?	8
Virginia creeper	*Parthenocissus quinquefolia*	10–50'	—	Grn	All	I	3–6	All	S	F	2	?	8
Wisteria	*Wisteria* spp.	10–40'	Sp	Grn	F,P	I	5–6	All	S	F	1	?	8

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University of Idaho Extension publications

Most UI Extension publications are available to download for free at http://www.cals.uidaho.edu/edcomm/catalog.asp

Ones in print can be ordered online or by calling (208) 885-7982 or emailing calspubs@uidaho.edu

How to Prune Coniferous Evergreen Trees (BUL 644) online and in print

How to Prune Deciduous Landscape Trees (BUL 819) online and in print

Roses: Care After Planting (CIS 796) print only

Cold Hardiness in Woody Landscape Plants: Its Role in Winter Survival and How to Maximize It (CIS 867) print only

Low Input Landscaping (CIS 1054) online and in print

Fertilizing Landscape Trees (CIS 1068) online and in print

Trees Against the Wind (PNW 5) online and in print

Grafting and Budding Plants to Propagate, Topwork, Repair (PNW 496) online and in print

Plant Materials for Landscaping (PNW 500) online and in print

Websites

Pacific Northwest Chapter, International Society of Arboriculture. http://pnwisa.org/

National Arbor Day Foundation. http://www.arborday.org

Arnold Arboretum. http://www.arboretum.harvard.edu/

Maps

Marc Cathey. American Horticultural Society Plant Heat Zone Map. http://www.ahs.org/pdfs/05_heat_map.pdf. To order ($9.95), telephone (800) 777-7931.

2012 USDA Hardiness Map. http://planthardiness.ars.usda.gov/PHZMWeb/

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Chapter 19
Herbaceous Ornamentals

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I. Introduction

Herbaceous ornamentals comprise the nonwoody portion of the garden landscape. These plants generally add color and interest to a basic landscape design and landscape structure. Whether that structure is a backdrop or basic design of trees and shrubs, or a purposeful laying out of beds and other types of planting areas, the addition of herbaceous ornamentals can enhance a landscape significantly. These plants are also forgiving because they are easier to dig and rearrange than most landscape trees and shrubs. Learning to use herbaceous ornamentals to the best advantage is easy; simply follow the guidelines outlined in this chapter.

II. The Art of Design

A. Color

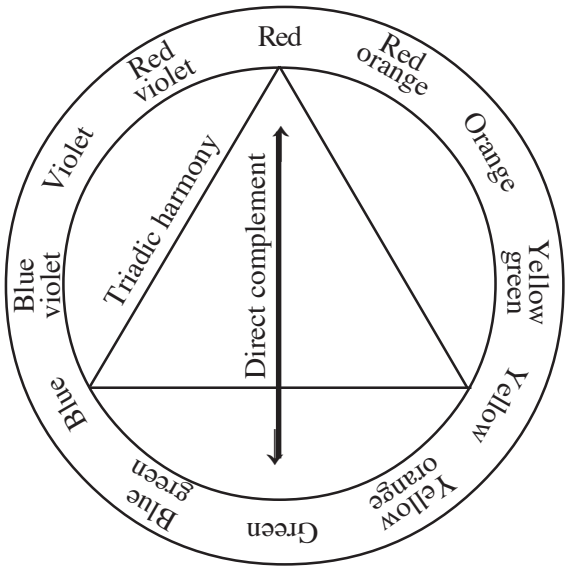
Herbaceous ornamentals are generally grown for their addition of color, through their flowers and foliage, to the landscape. Understanding the impact of colors and how to combine them can form a basis for use of these versatile landscape plants (Fig. 1).

Several color schemes can be created in a single garden by planting early season blooming plants in one color scheme and late-blooming plants in a different scheme. An interesting overlap can occur in plans of this type.

The primary colors are red, yellow, and blue. Other colors are combinations of these primary colors. A pure color is a hue. A lighter version of a hue is a tint, which is accomplished by combining a hue with white. A darker version of a hue is a shade, a color made by combining a hue with black. A tone is made by combining various amounts of black and white, or gray, with a hue. The value of any color is the brightness of that color compared to another. Pure yellow has a greater value than pure blue.

The warm colors of yellow, red, and orange will brighten cool, shady areas. These colors are attention getting and can be used to the advantage at the back of a long bed to shorten the perspective. The cool colors of violet and blue, by contrast, recede and are good for close-up viewing. Cool colors are used to the advantage in lending a cooling illusion to any overheated area such as a concrete patio.

Fig. 1. The color wheel.



Color schemes effectively used with herbaceous ornamentals are:

1. *Polychromatic*—Uses all the colors and their tints, shades, and tones. This can produce a carnival effect, and often results in some very pleasing color combinations.
2. *Monochromatic*—Uses the various tints, shades, and hues of only one color. Gardens using this color scheme are particularly dramatic.
3. *Analogous*—Uses adjacent colors on the color wheel such as blue, violet, and red. Such a color scheme can be expanded by using the various tints and shades of each of the colors.
4. *Complementary*—Uses opposite colors on the color wheel such as red and green, orange and blue, and yellow and violet. This type of color scheme is most effectively used with pure hues (not tints or shades) and creates a very bold effect. This color scheme is not recommended for the small garden.
5. *Split Complementary*—Uses a pure color and a color from either side of its complementary counterpart. An example of this is starting with blue and combining it with red or yellow, the colors bordering orange on the color wheel.
6. *Triadic*—Uses three colors that are equal distance from each other on the color wheel. This unusual idea is striking.
7. *White*—This color deserves a special comment. There have been many famous gardens planted in white flowers alone. There is a special appeal in the contrast of white against the green foliage of plants. White will give your garden a well-planned and orderly look. It is the last color to fade from sight as darkness falls, so it is a good choice for "evening" gardens. Cream and ivory flowers blend well with all colors except yellow.

B. Texture

This is dictated by the density and size of individual leaves and flowers. Plants with large leaves and large bold flowers have a coarse texture, tend to be dominant in a garden, and appear to advance to your field of vision. Plants with tiny leaves and small flowers lend a fine texture to the landscape, and tend to recede in your field of vision. Choose herbaceous ornamentals according to the textural "feel" you wish to attain. Often a mix of all textures is most visually pleasing.

C. Shape and Size

Herbaceous ornamentals come in all sizes and shapes. Size is comprised of height, or tallness, and spread, or the extent to which the herbaceous ornamental covers the ground at maturity. A shape is the same as the habit or form of a plant. Some herbaceous ornamentals hug the ground, while others tower to 6 feet or more; others are vines. Some are compact ball-shaped plants while others are open and upright. There are herbaceous ornamentals perfect for any location. Be sure to space plants far enough apart to allow room for each to develop to maturity.

III. What to Plant

A. Exposure

Herbaceous ornamentals can be adapted to all types of sites from full sun to pure shade. Choosing a plant according to the exposure of the site ensures success with these plants.

B. Season of Flowering

Some herbaceous ornamentals are tolerant of cool temperatures and bloom in early spring. Others need warmer weather and bloom in the summer. Still others bloom in the fall. Choose the proper herbaceous ornamental based on when color in a particular area is most desirable.

C. Cut and Dried Flowers

Some kinds of herbaceous ornamentals hold up better as cut flowers while others dry beautifully. Choose herbaceous ornamentals that are adapted to fresh or dry display.

Special cutting gardens can be completely harvested for flowers without concern for how the garden looks. However, plants valuable for cut flowers can usually be incorporated into the main garden.

When cutting for air drying, choose flowers just reaching maturity. Strip off the foliage, and hang upside down in small bunches in a

dry, shady spot. Some flowers will dry well standing upright in a container.

D. Herbaceous Ornamentals That Naturalize

Some herbaceous ornamentals, such as native plants or wildflowers, reseed themselves prolifically and eventually will naturalize an area. Know which plants have this tendency, and choose the proper annuals for naturalizing. Remember, any hybrid ornamentals that reseed will not come true-to-type, and usually will produce an offspring of inferior plant quality. Seedlings of this type are not desirable.

E. Special-Use Gardens

Herbaceous ornamentals are used to create gardens with special qualities such as rock gardens, bog gardens, prairie and meadow gardens, cottage gardens, cutting gardens, fragrance gardens, herb gardens, or traditional herbaceous perennial gardens.

IV. How to Plant (Design)

A. Formal and Informal

Once you have decided where to plant herbaceous ornamentals, decide on a design. Formal designs are composed mostly of straight lines and symmetry. What appears on the right side of the garden is matched on the left. A formal design is easy to lay out and, because of its visual simplicity, is the best choice for a small lot.

Informal gardens are composed of curved flowing lines and a disregard for symmetry.

B. Beds and Borders

Beds are large blocks of planted areas. The bed requires a relatively large area around it to look its best. If you have a large yard you may have the perfect spot for a bed.

Borders run along the edges of shrub beds, buildings, fences, walkways, and lawns. They conserve space and soften the edges of whatever they border.

As a general rule, the sum of the widths of the beds and borders should not exceed one-third of the width of the yard. Also, individual beds should be no more than five-eighths to two-thirds as long as the long axis of the yard.

Herbaceous ornamentals can also be tucked here and there in a shrub or perennial bed or border to provide a spot of seasonal color. Avoid spots, however, where water-greedy roots of trees and shrubs will interfere with growth. In these spots, a container of herbaceous ornamentals will provide better results.

C. Plant Choice

Materials will depend on the desired effect and will be influenced by color scheme, season of flowering, texture, diversity, type of background plants, and available space. When designing the bed or border, remember to place the lower growing plants to the front so that they will be visible and not shaded out by taller types.

Since it is easier to place the tallest plants first, design the border from the back to the front; the bed from the middle to the edge. Design from fall to spring rather than spring to fall. This ties in with the suggestion to design from the back to the front of the border and from the middle to the edge of the bed, since fall plants are often taller and would logically be placed in the back of the border or the middle of the bed. Finally, because you read from left to right, design from left to right.

Plant in clumps or drifts of plants using groups of the same species or cultivar. When planting in groups of less than 10, plant odd rather than even numbers of the same plant. These design suggestions help avoid the “zoo” effect (a collection of one of everything) and will lead the eye through the planting.

V. Gardening in Containers

Almost any annual can be grown in a container. Plants that spread or cascade are suitable for the outer rim of regular containers and for hanging baskets. If plants are mixed in a container, all should have similar sun and water requirements. Containers and hanging baskets allow the gardener to provide spots of color almost anywhere around the home grounds.

A. Containers

Choose a container with holes in the bottom to drain the water. A tray underneath will catch any drainage. Avoid letting pots rest in standing water, as roots may begin to rot. Glazed clay pots and plastic containers do not breathe and will not need watering as often as clay. Darker colors absorb more heat, which will warm the soil but cause more water loss. Therefore, light-colored containers may be the best choice for most gardeners.

B. Soil

For containerized plants, purchase a commercial potting mix that is a blend of peat, pearlite, and other components and contains no soil. Mixes are blended to hold water and nutrients and to drain well. Mix some slow release fertilizer with the mix, or liquid feed about every 2 weeks. Water containers well before applying liquid fertilizer.

C. Planting

Containers look best when packed with plants. A planted container should look attractive immediately after or within a few weeks of planting.

D. Watering

Plants in containers require regular watering. Always water until the water runs out of the drain holes. Water can run right through very dry soil without actually wetting it. If you have doubts, tip the container up to test that it has become much heavier with water.

E. Maintenance

Herbaceous annuals make excellent long-flowering container plants. However, perennial container plants can be placed in the garden after their limelight. If containerized perennials are not planted out in the garden, place them in a cold frame or garage to protect their roots from freezing during the winter.

VI. Getting Started with Annuals

An annual plant completes its life cycle in a single year. Unless the plants reseed themselves, new annuals need to be planted every season. Some hardy annuals have seeds that will germinate and grow in cooler soil. The plants will stand some freezing and thawing. Half-hardy annuals will take some cool, damp weather but will be killed by a frost. Tender annuals can take no cool weather at all. Some annuals will reseed depending on variety and climatic conditions.

Annuals serve many functions in the garden, but their primary use is for providing color. They grow quickly and easily, are great for cutting, and are generally inexpensive. Annuals generally bloom for most of the season. An added bonus is the fragrance that some annuals bring to the garden. Annuals come in a variety of sizes, shapes, and colors.

A. Propagation

1. Seeds—Come in mixtures and single cultivars. Hybrid seeds are usually more expensive but often produce spectacular flowers. If you save your own seed, be aware that most flowers, and especially hybrids, will not breed true-to-type. Seeds will lose their viability if stored for many years, so starting with fresh seed packaged for the growing year will get you off to the best start.

   Seeds that are started indoors or in a greenhouse should be growing 4 to 6 weeks before you place them in the garden. The warm weather annuals should be transplanted outdoors after the danger of frost.

   The easiest way to begin annual plants is to plant the seeds directly where you wish the plants to grow. The seedlings can be thinned to achieve the desired density. Follow the seed package instructions for time and depth of planting.

2. Transplants—Plants from the garden center save you time and effort. They are, however, more expensive than growing your own. Some flowers such as petunias, impatiens, and geraniums have very small seeds, are slow to germinate, and seedlings take longer to reach transplant size. They can be started indoors, but they demand precise growing conditions and vigilant care. It is easier to buy transplants for these types of plants.

Pick good plants. Make sure plants are healthy and growing vigorously. Plants that have obviously dried out, have overgrown their containers, or are yellow or leggy should be avoided because they will bloom poorly and require constant watering.

Slip plants out of their containers to check the roots. Look for a fine network of healthy roots supported by visible soil. Avoid plants with a mass of dense, white, tangled roots.

B. Growing, Culture, and Maintenance

1. Soil preparation—A soil test is always a good idea if there is any doubt about the fertility or pH of the soil. Amend the soil appropriately before planting to adjust the acidity and provide the proper nutrients for growth.

   Amendments, such as compost, peat moss, and manure added to the soil will increase organic matter, and thereby increase water-holding capacity and soil fertility. Covering the soil surface with a 3-inch layer of amendment and digging it into a 12-inch depth provides a good planting area.

2. Planting—Seeds will germinate when the soil is warmed to the proper temperature. The exact temperature will depend on the annual species being planted.

   After the soil is prepared, sprinkle the seed either randomly or in rows with indentations in the soil. Cover the seed with loose, organically amended soil, so the soil will not crust over the seeds. Water in with a light misting of water, and keep the soil evenly moist until germination occurs. Be sure not to plant the seed any deeper than suggested on the seed package label.

   Acclimate transplants before placing them in the soil. Place them in a protected space outdoors for several days, and make sure the plant does not dry out. At planting time, tap or tip the plants out of their pots, and set them in a prepared hole large enough for the root ball to fit comfortably. Set the plant in the hole, making sure the top of the root ball is even with the surrounding soil surface. Recent research has shown that breaking up the root ball of even the most pot-bound of annuals only slows down their development. Plant the roots as they come out of the container. Do not let the root ball dry out. Firm the soil around the roots and water well. Protect plants against excessive sun, wind, or cold while they are getting started. Inverted pots or milk cartons, or row covers can be used.

3. Fertilizing—Dry or liquid fertilizers will work for annuals. Nitrogen stimulates leafy growth, while phosphorus and potash promotes flowering, fruiting, and root growth. Fertilizers with a *ratio* of 1-1-1, 1-2-1, or 1-2-2 are best for annuals. Remember that the numbers on the package indicate both the ratio and the percentage of active ingredients per pound of nitrogen-phosphorus-potassium.

   Dry fertilizer amendments added at planting will last for about 6 weeks. Application of dry fertilizers, followed by a watering, or liquid fertilizer applied to damp soil will maintain the quality of the plants and blooms.

4. Watering—Young plants need more frequent watering until their roots get established. Sown seeds may need multiple daytime watering. As plants become established, gradually water less frequently. Watering established plants will depend on plant size, soil characteristics, and weather. During hot weather, large plants in sandy soil require frequent watering. Strive to keep the plants evenly moist. If plants are allowed to dry out, they may be permanently stunted.

   Overhead watering with sprinklers is a common technique. However, some flowers are more susceptible to disease if their leaves and flowers are constantly wet. Overhead watering can also cause taller plants to tip over.

   Furrow watering is a common technique if planting is done in rows. Furrows must be tended so the water flows properly, and there must be a gentle slope from one

end to the other. Once plants get large, the furrow system can be difficult to maintain.

Drip irrigation is the most efficient way to deliver water. Use drip emitters or perforated tubing to deliver water directly where you want it.

Infrequent deep watering is better than frequent light applications.

5. Mulching—This helps annual plants conserve moisture and keeps the soil cooler. Be sure to apply the mulch after the soil has warmed in the spring, otherwise warming will be delayed. Mulches also help in weed control and provide an attractive appearance. Organic materials, such as bark or sawdust, can be incorporated into the soil at the end of the season as an organic amendment.

   Mulch materials must allow water to move through. Organic materials must be loose and coarse. Remember that many organic materials will draw nitrogen to the soil to aid in breakdown. These materials, when used as mulch, must be augmented with nitrogen fertilizer. Wood byproducts, such as bark chips and sawdust, as well as compost make good mulch for annuals. Pine needles and grass clippings can also be used. Spread grass clippings in one thin layer and allow them to dry before adding another layer.

   Landscape fabric can be spread over the soil surface and covered with bark chips or other organic materials. The fabric stops weed growth, but allows air and water to penetrate the soil.

6. Thinning—Seedlings grown from directly planted seeds need to be thinned. This process is little more than pulling out the excess seedlings to establish the proper spacing for the type of annual grown.

   If pulling will disrupt the roots of the remaining plants in the garden, clip off the extras at the soil line with shears. Leaving more plants than necessary at this first thinning will provide some plants to be transplanted elsewhere and also allow a margin of safety in case of disease or frost problems. After plants are well established, a second thinning will leave plants with plenty of room to attain a mature growth. Properly spaced plants are healthier and produce more blossoms.

7. Pinching—Removing the terminal growth on young annual plants will help make them bushier and more compact. Many annuals are now bred to be compact and well branched. However, any plant that has become too leggy or too tall will be improved by pinching. Examples are petunias, geraniums, and many chrysanthemums.

   Pinching out the first blossoms that form on some plants will cause more overall bloom. Examples are marigolds and zinnias.

8. Weeding—These rob annual plants of nutrients and water and make them look unkempt. Weed problems can be reduced by proper soil preparation and mulching immediately after transplanting. In direct-seeded areas, apply mulch to retard weed growth after plants have been thinned.

   If weeds grow among annuals, hoe only deep enough to sever the weeds just below the surface. This will avoid any damage to the shallow feeder roots common to annuals. If weeds are large, pull them by hand.

9. Deadheading and grooming—Removing the faded flowers, or deadheading, will help keep the garden looking neat and will prolong bloom on most garden annuals. A plant that is ripening seeds produces less blossoms. Pinch off or cut spent flowers back to the next branch. Shearing the flower heads with pruning shears works well for smaller-flowered plants. Be careful not to cut back too far. Remove less than one-third of the plant.

   Grooming annuals involves removing dead leaves and thinning extra branches. Grooming keeps plants looking good and, by removing dead foliage before it can mold on the plant, keeps diseases from gaining a foothold.

   Thinning the foliage keeps the air circulating through the plants, keeps the plants

dry, and cuts down on diseases. Thinning also allows light penetration to the interior of the plant. Often insect pests, which otherwise might be overlooked, are discovered during the grooming.

10. Staking—Tall growing annuals such as larkspur and tall marigolds need protection from wind and rain or overhead sprinklers. Stakes help them grow straight and keep them from being knocked over.

    Stakes can be made of wood, bamboo, or any similar material. To be less conspicuous, stakes should be small in diameter and about 6 inches shorter than the mature plant to avoid being visible above the plant. Secure the stems to the stakes with paper-covered wire, plastic ribbon, or other material that will not cut into the stem, You also can support the plants with a framework of stakes and strings in crisscrossing patterns. Commercial support frameworks are available for herbaceous annuals.

    Stake plants before they have a chance to fall over or begin to grow crooked. When plants are about one-third of their mature size, begin staking. Place stakes or frames close to the plant, but take care not to damage the root system. Secure the plant stems to the stake or frame as it grows taller.

11. Insects—Although ornamental annuals are generally pest-free, the following insects can sometimes cause problems: aphids, beetles, caterpillars, thrips, white flies, earwigs, and mites.

    Annuals that are well maintained can withstand most attacks by insects. Plants under water stress or those lacking plant nutrients become more susceptible to insect attack. Keeping annuals healthy and growing is the first line of defense. Many insect pests are naturally controlled by predator insects. Chemical sprays will destroy these predators and should be avoided.

    Insects, such as aphids, mites, thrips, and white flies, can be controlled with insecticidal soaps. Caterpillars can be controlled with Bt spray. Earwigs can be trapped in rolled newspapers and then destroyed.

    If chemical treatment becomes necessary, make sure your pest is positively identified and use a chemical appropriate for its control. Always follow label directions.

12. Diseases—Since annuals are only in the garden for one season, diseases are not as serious a problem as they are for perennials. The following diseases, however, can sometimes cause problems: the fungus diseases botrytis blight (gray mold), damping-off fungus, powdery mildew and rust, and the virus diseases mosaic and aster yellows.

    Moist conditions and splashing water favor and spread the fungus diseases rust, powdery mildew, damping-off fungus, and botrytis blight. Spacing and grooming plants correctly to maintain a good airflow will help to prevent these diseases. Sprinkler watering in the morning so the foliage will dry during the day or drip irrigating so the foliage stays completely dry will also help. Damping-off can be prevented by planting seeds after the weather warms and not keeping the seeds and seedlings too wet.

    Botrytis gains a foothold in dead plant parts. Deadheading and grooming can help to keep this disease out of annuals.

    Insects such as aphids and leafhoppers spread the virus diseases mosaic and aster yellows. Starting with virus-free plants and then excluding insect pests will detour these diseases. No control is available for the virus diseases. Plants must be pulled and destroyed. The fungus diseases are controlled with fungicides. Check the label of each chemical for the organisms controlled and proper application methods.

13. Other pests—Slugs and snails are very common and can chew small annuals down to nothing. Handpick, trap, and destroy the pests, or use commercial baits.

C. Description of Selected Annuals

1. *Antirrhinum majus* (Snapdragon)—Available in many colors. Grows in full sun. Height varies from 12 inches for dwarf plants to 36 inches for the tall varieties. Plants can be directly seeded or transplanted in early spring. These plants often reseed themselves under Idaho conditions.
2. *Begonia semperflorens* (Bedding begonia)—Colors in shades of red and pink, and white. Leaves are bright green or bronze-red and waxy looking. Grows in partial sun to shade. Height is 6 to 12 inches at maturity. Seeds are slow to start and are best used as bedding plants or houseplants.
3. *Calendula officinalis* (Pot marigold)—Flowers are white, cream, orange, yellow, and apricot. Grows in full sun. Mature height is 12 to 30 inches. Sow seeds directly in early spring. Flower petals are edible, and the flowers make long-lasting cut flowers. These plants are very easy to grow and will reseed profusely.
4. *Callistephus chinensis* (China aster)—Asters come in white, light yellow, pink, red, blue, and lavender or purple. Grows in full sun. Height varies from 6 to 30 inches. Sow seeds directly into garden in spring. These plants dislike being transplanted. Many flower forms are available, and they all make excellent cut flowers.
5. *Centaurea* sp. (Bachelor's button)—Colors vary from blue, pink, rose, purple, yellow, and white. Grows in full sun. Height is 12 to 36 inches tall. The different species have differing planting and growth requirements.
6. *Cosmos* sp. (Cosmos)—Colors are yellow, orange, red, white, pink, and bicolors. Grows in full sun to partial shade. Height is 2 to 7 feet. Easy-to-grow plants make good backgrounds for other annuals. Several different species have differing planting and growth requirements. These plants will reseed.
7. *Dahlia* sp. (Dahlia)—Comes in all colors except blue. Requires full sun for at least half the day. Height is 12 to 20 inches. These seed-grown plants will form tubers that can be dug and stored over the winter. To assure vigorous bloom, however, replant each spring from seed. These showy plants will bloom profusely in the first year.
8. *Ipomoea tricolor* (Morning glory)—Colors include blue, white, pink, red, chocolate, crimson, lavender, and violet. Grows in full sun. This climbing plant will grow to 10 feet, but some dwarf forms are available that grow to 5 inches. This fast-growing vine is attractive on trellises and fences. Flowers on old varieties are open only at night, but the newer varieties stay open most of the day. Several different species are available. Some will reseed.
9. *Lathyrus odoratus* (Sweet pea)—Comes in pink, red, purple, lavender, white, cream, apricot, salmon, maroon, and bicolors. Prefers full sun. Climbing types will grow to 5 feet while bush types grow to 12 to 36 inches. Can be planted very early. Keeping seed pods off plants will keep it blooming.
10. *Limonium sinuatum* (Statice)—Colors include blue, lavender, white, rose, yellow, apricot, and peach. Prefers full sun. Grows 10 to 48 inches tall. This plant is easily dried and is decorative in bouquets. Various forms yield plants of differing heights. *L. sinuatum* has flowers in flat-topped clusters while *L. suworowii* has curved spikes of bright rose or lilac flowers.
11. *Lobelia erinus* (Lobelia)—Colors include white, cream, rose, pink, purple, violet, and lavender. Grows in full sun to light shade. Height is 4 to 6 inches. Lobelias are easy to establish as transplants. Flowers best when nights are cool. Attractive in front of other annuals and in containers and hanging baskets.
12. *Pelargonium* sp. (Geranium)—Comes in shades of red, pink, orange, violet, white, and bicolors. Grows in full sun to partial shade, depending on variety. Height is 8 to 36 inches. These popular annuals can be planted as rooted cuttings or as transplants in spring. Several different species

have differing growth habits. All make good houseplants. They can also be overwintered in a cool, unheated cellar.

13. *Petunia hybrida* (Garden petunia)—Colors available include shades of pink, red, salmon, coral, yellow, cream, blue, purple, white, and bicolors. Plants prefer full sun. Height is 8 to 27 inches. They are best started as transplants. The long blooming period of petunias make them a popular annual. Flowers are single or double. The plants are adapted to a wide range of soil and water conditions. They also make good cut flowers.
14. *Portulaca grandiflora* (Moss rose)—Colors include white, cream, yellow, orange, red, and pink. Grows in full sun. Height is 6 inches. Sow seeds directly or set out transplants. This favorite grows in sunny, dry areas where many other plant will not grow. Plants have a trailing habit, and the leaves are succulent. Flowers are single or double and open in the sun and close in late afternoon. These plants look good in rock gardens, containers, and hanging baskets.
15. *Tagetes* sp. (Marigold)—Colors available include white, off-white, yellow, orange, and orange-red. Plants grow in full sun. Height is 4 inches to 4 feet. They are easily established from seed or as transplants. Marigolds bloom continuously from early summer until frost. All are good as cut flowers. The many different species have various flower forms and plant growth habits.
16. *Tropaeolum majus* (Nasturtium)—Colors include cream, yellow, orange, red, and pink. Plants grow in full sun. Height varies from 15 inches in the dwarf varieties to 10 feet in the climbing types. They are easily established from seed, but plants do not transplant well. Young leaves and blossoms have a peppery flavor and are edible. Blooms profusely throughout the summer until frost.
17. *Viola* sp. (Pansy)—Colors available include white, yellow, orange, red, purple, blue, and bicolors. Plants grow in full sun or partial shade. Height of plants is 8 inches. Violas are easy to establish as transplants are popular for containers, hanging baskets, and rock gardens. These plants grow best in early spring through early summer. Some varieties are more heat tolerant than others. The various species have various flower and growth characteristics. They will bloom all summer in cool regions if plants are deadheaded but will need to be replaced in hot summer climates.
18. *Zinnia elegans* (Garden zinnia)—Comes in shades of white, yellow, orange, red, pink, purple, and bicolors. Plants grow in full sun. Height is 6 to 36 inches. Zinnias are easily started from seed. These plants grow easily and bloom through the heat of summer and into late summer when most other annuals have finished. Available in dwarf and tall growing varieties.

VII. Getting Started with Biennials

Biennial plants complete their life cycle in 2 years. During the first year plants produce leaves that are often close to the ground and arranged circular in nature. This rosette of leaves overwinters, and the winter cold period stimulates flowering during the second year. The plants bloom and then die.

Biennial seeds can be planted in midsummer to produce plants that develop in the fall. The plant will then bloom the next year. Popular biennials are stock, foxglove, silver dollar, and hollyhock.

Culture of biennials is the same as for annuals except the plants remain for 2 years.

VIII. Getting Started with Perennials

Historically, herbaceous perennials have always been an important component of the ornamental garden, and recently there has been an upsurge of interest across the United States in the culture of herbaceous perennials. Despite this renaissance, many gardeners are reluctant to try growing herbaceous perennials because they still lack appreciation and knowledge about them.

Herbaceous perennials take the name *herbaceous* from the word *herb*, a seed-producing annual, biennial, or perennial that does not

produce woody stems. Herbaceous perennials are termed *perennial* in that they take one or more seasons to go from seed to seed, and then generally, but not necessarily, live for three or more seasons. Some, such as columbine, may be short-lived, while others such as peony will outlast several generations of the same family in the same site without being divided or moved.

The tops of the plants, the flowers, the leaves, and the stems of herbaceous perennials usually die back to the ground with the first fall frost. The hard, fleshy subterranean portions of the plant, the crown and roots, survive the winter and resume growth in spring. Those herbaceous perennials that survive the winter with little or no protection are termed *hardy*. Those herbaceous perennials that need some protection to survive the winter outdoors are said to be *half-hardy*. Some herbaceous perennials must be lifted as tubers, rhizomes, or bulbs, stored overwinter or placed in a greenhouse, and then be replanted in spring. These plants are termed *tender* herbaceous perennials.

Herbaceous perennials are available in an unlimited variety of flowers, foliage colors, textures, forms, spreads, and height. As a group, herbaceous perennials are the first plants to bloom in the spring and the last to fail with the fall frosts. They seldom bloom more than a few days to several weeks as individuals, but afford a continuity of bloom as a bed or border.

Being herbaceous rather than woody, herbaceous perennials have the capacity to bend in the breeze and lend interest and movement to a static landscape. They have the advantage, unlike trees and shrubs, of obtaining a definite size each season, somewhere between a few inches to 10 feet tall. Generally, herbaceous perennials need division and no pruning.

Herbaceous perennials vary in their environmental preferences from wet to dry, fertile to infertile, low to high pH, sandy to loam to clay soils, as well as shady to sunny sites. They also vary widely in the amount of care they need. While there are no maintenance-free herbaceous perennials, there are many that require low maintenance.

A. The Purpose of a Perennial Garden

A perennial garden may have different purposes and fill many needs. The great English gardener, Gertrude Jekyll (1848-1933), perhaps said it best when she penned:

> *"The first purpose of a garden is to give happiness and repose of mind, which is more often enjoyed in the contemplation of the homely border…than in any of those great gardens where the flowers lose their identity, and with it their hold of the human heart, and have to take a lower rank as mere masses of color filling so many square yards of space."*

Among the uses of a perennial garden might be to:

- Enhance those outdoor areas where you will spend much of your time from spring to fall.
- Create an attractive privacy screen.
- Soften and make attractive a steep slope by terracing it and planting herbaceous perennials.
- Create a bog garden where it is too wet for a lawn.
- Create an inviting entrance to your house.
- Grow flowers for indoor or outdoor fragrance.
- Integrate the other features of the landscape into a whole.
- Create a special place to exhibit your skill at raising specimen plants.
- Mask unattractive aspects of the yard such as tool sheds, garbage cans, compost bins, etc.
- Use a rocky outcropping as a rock garden rather than trying to remove the rocks.
- Create a stunning view from inside the house.
- Add color, shape, and dimension to the small yard patches next to entrances, which will soften the hard features of the existing backdrop.

B. Sexual Propagation by Seed

This method is advantageous because disease is not as easily carried over on the seed as it may be through vegetative propagation.

To start herbaceous perennials from seed, harvest the seed when it is ripe but before the spent flower heads self-sow. Keep in mind that seeds of many horticultural cultivars will not come true-to-type owing to its hybrid parentage. To start perennials from seed indoors, start them in midwinter to early spring so some of them will bloom the first growing season. Seeds may be started in a greenhouse or a sunny window but most commonly are started under lights.

C. Vegetative Propagation by Division, Stem Cuttings, Root Cuttings, Layering, Grafting, or Tissue Culture

Vegetative propagation guarantees that the offspring will be identical to the parent. Usually it takes far less time to have a fully mature blooming herbaceous perennial when it is vegetatively propagated.

1. Division—This is the simplest and most certain way to propagate, control the size of, and rejuvenate herbaceous perennials. Generally, perennials become larger each year and eventually begin to choke out other plants. Their outer edge thrives while the center of the clump suffers from competition for water, nutrients, root run, and sunlight. Often an advanced-age clump looks like a doughnut with a thriving outer ring and a dead center. Such a clump is a prime candidate for division. Shasta daisies, chrysanthemums, and phlox are good examples of plants where this condition exists after 2 to 3 years.

   The time to divide a perennial clump depends upon the particular perennial, the time of year that the perennial blooms, and the climate. In Zone 5 or colder, most division is done in the spring while the perennials are still slightly dormant. Division is usually necessary only every 2 to 4 years for most perennials. Some perennials such as the chrysanthemum benefit from being divided every year while others, such as the oriental poppy, are best left undisturbed for as long as possible, or never divided.

   Different types of perennials are handled differently depending upon their growth habit when they are dug and divided. For example, compact shallow-rooted plants are divided by digging the entire clump and pulling it carefully apart into smaller plants. Solid clumps of plants such as daylilies, hosta, phlox, and Siberian iris are divided by digging up the entire clump and using two spading forks back-to-back to pull the clump into sections. If the center of the clump is deteriorated, it must be discarded. If you wish to have a small section of an existing clump for use elsewhere, use a sharp spade to dig a healthy section away from the parent clump without disturbing the parent clump.

   Shallow-rooted ground covers such as vinca and creeping phlox are divided anytime during the growing season by digging them up and cutting them apart.

   Fibrous- to woody-rooted perennials such as lupine must be dug carefully, the soil rinsed from the roots, and then the crown carefully divided with a sharp knife, making sure that each segment contains two to four strong tap root segments and two to four eyes or shoots.

2. Tip or stem cuttings—These are rootless sections of plants that are placed in a rooting medium where they are induced to develop adventitious roots. Cuttings may also be taken from actively growing roots.

   Tip or stem cuttings are propagated by taking a terminal, 3- to 6-inch long firm portion of a vigorous nonblooming shoot that includes several nodes. Spring is the best time to take cuttings from herbaceous perennials that bloom in summer. Early summer is the best time to take cuttings from those that bloom in spring or fall.

   Most perennials cuttings should begin to develop roots in 1 to 2 weeks. Bottom heat will speed the rooting process but is not necessary.

   Sometimes young, virtually rootless tufts of shoots develop at the base of the perennials. These may be pulled away from the parent plant and treated the same as any cutting.

3. Root cuttings—These cuttings are best made in early spring. While it is easiest to take cuttings from perennials when they are being lifted from the bed or border, cuttings can also be taken from the parent plant by digging around the periphery of the parent plant with a shovel.

   Fine-rooted plants, such as achillea, are propagated from root cuttings by scattering 1- to 2-inch long sections of root horizontally on the surface of a 2- to 3-inch deep layer of moist soilless medium in a flat. Cover the pieces of root with 1/2 inch of moist sifted, soilless mix.

   Fleshy-rooted perennials such as baby's breath, bleeding heart, peonies, and oriental poppies are propagated by taking 1 1/2- to 2-inch long sections of roots, dusting the bottom end with a rooting compound, and sticking the root cutting bottom end down in a 50-50 mixture of peat moss and sand in pots or deep flats, with 1/4 inch of the cutting sticking above the rooting medium. For peonies, take 3-inch long root cuttings and keep the medium moist but not wet. When the cuttings begin to grow, treat them the same as any other seedlings.
4. Layering—This is an easy way to propagate vine-type plants and ground covers. Bend the supple stems, without severing the stem from the parent plant, down to the soil into a shallow trench and cover several nodes with soil, or bend the stems into pots of soil.
   Notching or wounding the area just below a soil-covered node will encourage rooting. Many upright plants can also be rooted with this technique by carefully bending their younger, more flexible stems downward to the ground.
5. Grafting—This is the joining of the top of one plant, the scion, to the bottom of another plant, the stock. This technique is possible but rarely used in propagating perennials.
6. Tissue culture—Millions of disease-free plants from a single small clump of apical cells in a single season can be generated from a tissue culture. This method is beyond the facilities and capabilities of the ordinary homeowner.

D. Vegetative Propagation by Specialized Stems and Roots

   These function primarily as food storage organs and can also function in vegetative reproduction.

   1. Bulbs—Tunicate bulbs have outer-bulb scales that are dry and membranous and are typical of the tulip, hyacinth, bulbous iris, and daffodil.

      Nontunicate, or scaly bulbs, are represented by the lily. These bulbs do not have the dry covering, and the scales are separate and attached to a basal plate. Propagation is accomplished by periodically removing the small bulbs or offsets that grow off of the main bulb. This is usually done whenever the plants are dug. Digging of these perennials is necessary when the clumps become too crowded and is done after the foliage has died down naturally in the late summer or fall. Bulbs should be planted or replanted at that time. The small bulbs may need to grow for several seasons before they are large enough to flower. Lilies are propagated by removing some of the outer scales of the mother bulb, planting them, and allowing them to develop small bulbs.
   2. Corms—Gladiolus and crocus are typical plants with corms. Gladiolus are semihardy to tender in Idaho and must be stored overwinter in areas with severe winters. The corm is a swollen base of the stem that is enclosed by dry, scaly leaves. Propagation is accomplished by separating the small corms or cormels from the mother corms. Plant these small corms shallowly and expect no flowers until they grow large enough, usually 1 or 2 years.
   3. Tubers—These are a modified stem that serves as a storage organ. Caladium is an example of a tuberous plant. Tubers can be propagated by planting the whole structure or by cutting tubers into sections, each containing one or more buds or "eyes." This division is done shortly before planting.

4. Tuberous roots and stems—These thickened structures are botanically different from true tubers but are often called simply "tubers." Tuberous roots are typical of several types of perennials, including the dahlia. Propagation is done by separating the tuberous roots, making sure that each root has a section of the crown with a shoot bud. Divide in late winter or spring, shortly before planting. Tuberous roots are biennial, meaning the old root disintegrates in the second year after new tuberous roots are produced.

   Tuberous stems include the tuberous begonia and cyclamen. These structures are usually vertical in orientation and have vegetative buds on the upper end. These tuberous stems continue to grow larger and larger from year to year. Divide these structures early in the spring, making sure each has a bud.

5. Rhizomes—These specialized stem structures grow horizontally on top of or just below the soil surface. Rhizomatous iris and lily of the valley are two perennials that can be propagated by their rhizomes. Remove sections of shoots and roots early in the spring or in late summer or fall.

D. Growing, Culture, and Maintenance

1. Site selection—Because herbaceous perennials can be left in a given place for a long period of time, proper site selection is critical. Most plants prefer a site that has a fertile, well-drained, organically rich soil with a pH of 5.5 to 6.5. Good drainage is important, especially during the winter, and most soils will have to be improved. The site should receive full sun or shade all day. Be sure to consider not only the present shade, but also the future shade. Take into account the growth of your trees and shrubs as well as your neighbor's. The site should be flat to only slightly sloped. It should be out of the drying, stem-snapping wind but have enough breeze to provide the air circulation essential to minimize the slow foliage-drying conditions conducive to disease.

2. Soil preparation—The best opportunity to tailor the soil needs of the perennial is the first time it is prepared. Try to start soil preparation long before planting the bed or border. Start in spring for a fall planting and in fall for a spring planting. This will allow plenty of time for any organic soil amendments and/or pH modifications to take effect. To prepare the site for planting perennials:
   a. Clear all large debris from the site. Kill and remove all existing vegetation from the site for composting. It may be necessary to re-treat the site to kill persistent perennial weeds such as quackgrass.
   b. Spread 2 to 3 inches of organic matter such as well-decomposed compost, aged manure, or peat moss over the surface of the soil before beginning to work it. Rototill or spade the organic matter into the soil to a depth of 8 to 12 inches. Add no more organic matter than one-third of the final amended soil volume. Do not work the soil when it is wet. Organic matter incorporation improves soil structure by providing the lignin that glues together the soil particles. Improved soil structure encourages water percolation and retention, aeration, and root penetration. Spread an organic mulch over the prepared bed or border. It is easier and tidier to spread the mulch before planting.
   c. Edge the bed or border in some fashion. An edging will be attractive and will help reduce the encroachment of the lawn.

3. Planting and transplanting—While bare-rooted perennials are best planted either spring or fall, container-grown perennials may be planted at any time during the growing season, though it is more difficult during the drought months of July and August. Freshly dug plants are best transplanted in spring or fall but may be moved all summer if you are careful. Perennials such as bearded iris, bleeding heart, peonies, and oriental poppies are

best transplanted immediately after their brief dormant period after bloom. When planting herbaceous perennials:

a. Dig a hole two times the size of the root spread of bare root perennials and one and one-half times the size of the root ball of container-grown perennials.
b. Soak the roots of bare root plants for several minutes in a starter solution of 1 tablespoon of 16-12-10 or 20-20-20 water soluble fertilizer dissolved in 1 gallon of water.
c. Water the potted herbaceous perennials with a starter solution before knocking them out of the container. Place your hand over the top of the pot with your fingers grasping the main stems, turn the pot upside down, and tap the pot rim on the edge of a hard surface or tap the bottom of the pot sharply with a planting trowel. Remove fiber pots from perennials because often pots do not decompose. Be sure to at least peel back the rim of peat pots below soil level or the rim will act as a wick, drying out the pot and the contained soil.
d. Some pot-bound plants may have to have the container cut away with snips. Score the soil ball, making three to five vertical cuts into the soil ball, top to bottom, with a sharp knife. The depth of the cuts will vary from 1/2 to 1 1/2 inches deep depending upon the size of the soil ball. Tease some of the soil away from the top, sides, and bottom of the soil ball.
e. Place the plant in the planting hole, making sure that the crown of plant is at the same depth as it was previously growing.
f. Work some organic matter one-fourth to one-third by volume into the soil. Place this mixture around the roots until the hole is half full. Settle the soil around the root system by mucking it in with the starter solution. Finish filling the hole with the soil-organic matter mixture.
g. Tamp the soil firmly around the root system. Leave a berm to facilitate watering. Water the newly planted perennials with the starter solution. Label the plants or make a map of the garden for future reference.

4. Fertilizing—Perennials need steady, but light fertilizing first in late March to early April, right after the last of the mulch is removed and growth starts. Use a 5-10-5 fertilizer at the rate of 2 pounds per 100 square feet of bed space. Fertilize two more times at the same rate about 6 weeks apart. Fertilize a final time in very late summer for fall-blooming perennials.

   If the perennial bed or border begins to lag a bit in midsummer, use a water soluble foliar fertilizer as a boost. Foliar feeding should always be thought of as supplemental to, rather than as a substitute for, granular fertilizers.

Note: Overfertilizing, especially with nitrogen, promotes vegetative growth at the expense of flowering and increases the need of staking for support.

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5. Watering—Frequency is dictated by climate and the presence of a mulch. Water early in the day to avoid going into the evening with wet, disease-susceptible foliage. Water thoroughly, to a depth of 8 to 10 inches, to encourage deep root penetration. Soil should dry out a bit between watering. Waterlogged soil will encourage root disease and excludes oxygen, resulting in shallow-rooted, drought-prone, unstable plants.
6. Mulching—Helps control weeds, reduces water loss, moderates soil temperature changes, prevents mud splattering of foliage and flowers, helps preserve surface soil structure, and adds nutrients to the soil as the mulch biodegrades.

   Winter mulch can protect perennials from excessive cold temperatures and harmful thawing on freezing cycles. Apply after the first cold weather has occurred and after the soil has frozen. Cover crowns with 2 to 6 inches of light, porous mulch.

Remove mulch in the spring or before plant growth begins.

Summer mulch can be applied after the soil warms up, about 4 to 6 weeks after the last of the winter mulch is removed. Try to coordinate the placement of the summer mulch so that it follows one of the fertilizations and weed-destroying cultivations. Apply between 1 to 2 inches of mulch. Be sure to keep the mulch away from the crown of the herbaceous perennial.

The best mulches to use are those that biodegrade to the point that they can be worked into the soil in late fall or early spring. Mulches in this category include compost, peat moss, or smaller-sized bark.

7. Thinning—Removing out some of the stems increases the potential size of the individual blooms produced by the plant. For the most part, thinning is not necessary as it decreases the mass of the plant and may reduce the overall bloom impact of the plant.
8. Pinching —Inhibits the natural legginess of many perennials such as chrysanthemums. Pinching the growing tips or shoots of the individual stems once in May or June removes the inhibition of the shoot tip, producing multibranched shoots. This produces a whole bouquet of smaller-than-usual individual blooms. The combined branched shoots give the entire plant a much greater overall blooming mass despite the smaller individual blooms. Chrysanthemums are pinched every 3 to 4 weeks with the last pinch occurring about July 15.

   Pinching also delays blooming. A soft pinch, just the tip of the stem, does not delay flowering as long as a hard pinch, which removes several inches and several nodes from the stems. Pinching also decreases the need to stake herbaceous perennials as the plants are more compact.
9. Weeding—This is important because weeds compete for nutrients and water. Weeds may be grassy or broad leafed and annual, biennial, or perennial. The unwanted offspring of existing perennials may also be considered weeds since many of them, especially those from hybrid parents, will not come true-to-type. Your first chore is to be able to distinguish weeds, even at the seedling stage, from desirable perennials. Once so distinguished, weeding can be done by hand, with shallow cultivation, with herbicides, or largely avoided by using mulches.
10. Deadheading—Removal of spent blooms or inflorescence improves the appearance of the herbaceous perennials and prevents the investment of energy in seed production. It also encourages the plant to continue blooming, and stimulates a second flush of weaker bloom in those plants such as delphinium and foxglove.

    A few perennials such as sedum 'Autumn Joy', Black-eyed-Susan, and ornamental grasses should be allowed to retain their seed heads for their winter interest.
11. Disbudding—The removal of all except the tip-most bud on each individual stem or branch of a multibranched stem produces large flowers on each stem or branch of that stem. Peonies are often disbudded in this fashion. The most spectacularly sized blooms can be achieved by taking a rooted cutting and limiting it to a single terminal bud on a single stem. One shortcoming of disbudding is that the second flush of bloom, which occurs after the terminal bud blooms and the axillary buds develop, is lost. Some gardeners remove the terminal bud to obtain a host of relatively large axillary blooms.
12. Staking—Giving a physical support to the individual stems or to the plant as a whole is often necessary for those perennials with a natural tendency to fall over because of their height, habit, or weight of blooms and foliage.

    Tall, single stems of perennials such as delphiniums, gladiolus, and hollyhocks may require individual stakes for support. Select bamboo, plastic, or metal stakes that will be at least three-quarters as tall as the individual stems they are to support when firmly anchored in the soil.

Tie the stems to the stakes with a figure eight loop with one loop around the stake and the other around the stem. This double loop acts as a spring giving the stem a chance to sway in the breeze. The loops can be made with paper-covered wire, floral tape, or other soft material.

Stake bushy, multistemmed, floppy perennials such as asters, chrysanthemums, and coreopsis by pushing a ring of stakes into the soil at a point slightly to the interior of the perennial. Select stakes that are 6 to 12 inches shorter than the ultimate height of the plant. Weave a cats' cradle of support between the stakes with green yarn or floral tape. Start 1 foot above the soil level and continue upward at 1-foot intervals until the last cats' cradle is 8 to 12 inches below the top of the stems.

Alternatively, push appropriate lengths of multibranched tree or scrub prunings or branched bamboo canes into the soil at the fringes of the perennial. Let the interweaving branches supply most of the support. Some twine or floral tape may still be needed to contain the stems of the perennials.

Place very strong, multi-legged 18- to 20-inch tall wire hoops around perennials such as peonies and oriental poppies that have very heavy blooms on supple stems.

13. Insects and diseases—Practices to prevent or reduce the chance of insect and disease problems include:
    a. Select insect and disease-resistant perennials.
    b. Give your perennials the very best growing conditions possible from the standpoint of soil, nutrition, watering, spacing, sunlight, and air circulation.
    c. Grow a variety of plants. A monoculture of a cultivar or of a few cultivars will be far more susceptible to insect and disease problems.
    d. Remove spent flowers, dead leaves, and other plant litter during the growing season when it can be a source of infestation. Clean up the bed or border thoroughly before winter to avoid any refuse harboring insects and disease over winter.
    e. Keep weeds out of the bed or border and the immediate area because they are a source of both insect and disease problems.
    f. Know what the most likely common pests of your perennials are and then monitor for them.
    g. Do not compost any diseased plants. If your compost pile reaches the 140°F to 160°F, most disease organisms and insect eggs will be killed. However, most piles never get this warm, especially in the outside portion. Fungus organisms will spread along with compost.
    h. When a problem is encountered, act immediately without using pesticides if possible. Cut off diseased portions of the herbaceous perennial, or remove seriously damaged plants entirely. Handpick large insects.
14. Pesticide control—Consult with your county Extension educator for the most bio-rational pesticide to use for your particular problem.

    Spot treat if possible. Use non-chemical, non-biological pesticides such as horticultural oils and insecticidal soaps.

    Use biological pesticides such as *Bacillus thuringiensis* for caterpillars, or those pesticides derived from natural sources such as pyrethrum, rotenone, ryana, or sabadilla. When using any pesticide, follow the label instructions for pest controlled and for plants for which the chemical is labeled. Always apply at the labeled rate as instructed. Buy small quantities of the pesticide to avoid disposal problems.

IX. A Selection of Perennials for Idaho

Idaho growing conditions are difficult on plants. During the summer, temperatures and light intensity are high and humidity is low.

This combination causes some plants listed for the eastern United States and lower coastal elevations to perform poorly in Idaho. On the following pages, Table 1 lists perennials avail-

able through the Idaho nursery trade or by mail-order that have performed well or are deemed worthwhile for trial in Idaho.

A. Common Name—Lists several names that the perennial might be called. Cross-referencing is done through the text for convenience. For example, hollyhock is listed under alcea. Hollyhock is also found under the common name, which refers back to alcea for more information.

B. Scientific Name—Since the common name leaves a lot of guesswork, the scientific name is included for clarity. Under the scientific name is a listing of cultivars (cultivated varieties) that may be available in your local nursery. The cultivar name (e.g. 'Pink Star') many times indicates flower color.

C. Height—Varies with fertilizer practices, placement with respect to light, soil conditions, and plant vigor. A range of heights is given for most plants. Determining exact heights will be the part of the joy of gardening. Keep records of your discoveries so that plants can be moved into more correct locations in the future. A perennial garden can be arranged and rearranged like furniture in your home.

D. Bloom Time —Gives you the chance to "orchestrate" and synchronize the blooming sequence. Use a sheet of paper to list and "orchestrate" your flower display.

E. Flower Color—Refers to flower colors available in the nursery trade. It does not necessarily refer back to the specific cultivars in the scientific name column.

F. Light Needed—Categorizes the plant into one or more light regimes: full sun is uninterrupted sunlight through the full day; partial shade is filtered sunlight through tree leaves or a minimum of 6 to 8 hours of sunlight per day; full shade indicates filtered sunlight through a dense foliage canopy or less than 6 hours of sunlight each day.

G. Landscape Use—Suggests planting locations as well as indoor uses such as cut flowers or dried flower arrangements.

Table 1. Perennials for Idaho.

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Achillea, dwarf (Woolly Yarrow)	*A. tomentosa* German hybrids, e.g., paprika	8"-10"	June-Aug	Yellow	Full sun	Borders, ground cover
Achillea, tall (Fernleaf Yarrow)	*Achillea* spp.	2 1/2'-3'	June-Aug	Yellow	Full sun Partial shade Full shade	Borders, cut flowers dry flowers
Aegopodium (Bishops Goutweed)	*A. poidigrarua variegatum*	8"-14"	June-Aug	White	Full sun Partial shade Full shade	Ground cover, will grow in poor soil
Ajuga	*Ajuga* spp. 'Alba' 'Bronze Beauty' 'Gaiety'	6"-9"	April-May	Blue White	Full sun Partial shade Full shade	Ground cover, edging rock gardens, beneath trees
Alcea (Hollyhock)	*Alcea rosea* (also Althea rosea) 'Majorette' 'Silver Puffs' 'Summer Carnival' 'Chater's Double Mixture'	2'-9'	June-Aug	White Yellow Pink Lavender Red	Full sun	Background borders, against fence or wall
Allium (Stars-of-Persia or Persian Onion)	*A. christophii*	15"-24"	Early summer	Silvery-violet	Full sun	Herb gardens, edging vegetable plots, containers, edible foliage, rockeries

Table 1. (cont'd)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Allium (Giant Onion)	*A. giganteum*	3'-4'	Early summer	Pink-purple	Full sun	Herb gardens, edging vegetable plots
Allium (Turkestan Onion)	*A. karataviense*	8"-10"	Late spring	Lilac-pink	Full sun	Herb gardens, edging vegetable plots
Allium (Golden Garlic or Lily Leek)	*A. moly*	10"-14"	Late spring	Bright yellow	Full sun-partial shade	Herb gardens, edging vegetable plots
Allium (Chinese Chive or Garlic Chive)	*A. tuberosum*	20"	Late summer	White	Full sun-partial shade	Herb gardens, edging vegetable plots
Allysum (Basket of Gold) (Gold Dust)	*A. saxatile* 'Compacta'	9"-10"	April-June	Golden yellow	Full sun	Rock gardens, dry walls, banks, fronts of borders
Anchusa (Forget-Me-Not)	*A. myosotis*	6"-8"	May-June	Blue	Full sun Partial shade	Borders, groupings
Anemone (Greek Anemone) (Greek Windflower)	*A. blanda* 'Blue Star' 'Bridesmaid' 'White Splendor' 'Pink Star'	3"-6"	April-May	Blue Pink Purple White	Full sun Partial shade	Rock gardens, perennial borders, naturalized
Anthemis (Golden Chamomile) (Golden Carguerite)	*A. tinctoria* 'E.C. Buxton' 'Kelwayi' 'Moonlight'	2'-3'	June-Sept	Yellow	Full sun	Perennial borders, cut flowers
Aquilegia (Columbine)	*A. hybrida* 'Mckana Giant' 'Mrs. Scott Elliot' 'Rose queen' 'Spring Song'	2'-3'	May-June	Blue Pink Purple Red Yellow White	Full sun Partial shade	Borders, naturalized settings
Arabis (Rock Cress)	*A. caucasica* 'Snow Cap' 'Spring Charm'	12"	Late March May	White Rose-tinted	Full sun	Rock gardens, dry stone walls, border, small area ground cover
Arenaria (Irish Moss) (Sandwort)	*Arenaria* spp.	2"-6"	May-June	White	Full sun Partial shade Full shade	Evergreen, ground cover, rock gardens, around stepping stones
Armeria (Sea Pink) (Sea Thrift)	*A. maritima* 'Brilliant' 'Laucheana' 'Royal Rose'	6"-15"	May-June	Pink White	Full sun	Edging, rock gardens, cut flowers
Artemisia (Wormwood) (Angels Hair)	*A. schmidtiana* 'Silver Mound' 'Pours Castle' 'Silver Brocade'	8"-12"	Foliage plant		Full sun Partial shade	Perennial borders
Asclepias (Butterfly Weed) (Pleurisy Root)	*A. tuberosa*	2'-3'	June-Aug	Orange	Full sun	Borders, dry flowers
Asperula (Sweet Woodruff)	*A. odorata*	8"	May-July	Pink Blue White	Partial shade	Ground cover, rock gardens

Table 1. (cont'd)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Aster, short/dwarf (China Aster) (Annual Aster)	*Callistephus chinensis* 'Pinocchio' 'Dwarf Queen' 'Color Carpet'	4"-10"	Spring Summer or fall	Many	Full sun	Cut flowers, bedding plants
Aster, tall (New England Aster) (Stokes Aster)	*Aster* spp. or *Callistephus* spp. or *Stokesia* spp.	11/2'-3'	Spring Summer or fall	Many	Full sun	Cut flowers, borders
Astilbe (False Spirea)	*Astilbe x arendsii* 'Deutschland' 'Fanal' 'Red Sentinel'	2'-3'	June-July	Red Pink White	Full sun Partial shade	Border plant
Aubretia (False Rock Cress)	*A. deltoidea* 'Bengale' 'Purple Cascade' 'Red Cascade'	6'	April-May	Rose-lilac Purple Red	Full sun Partial shade	Rock gardens, dry stone walls, edge of perennial borders
Baby's breath (see Gypsophila)						
Basket of gold (see Allysum)						
Bellflower, Chinese or Japanese (see Platycodon)						
Bellis (English Daisy)	*Bellis perennis*	4"-6"	April-June	White Pink	Full sun Partial shade	Edging, borders
Bergenia (Heartleaf Berfenia) (Pig Squeak)	*B. cordifolia*	12"-15"	April-May	Pink White	Full sun Partial shade	Evergreen, rock gardens, stream banks, pools, perennial borders
Betonica (Lamb's Ear) (Woolly Betony)	*Stachys byzantina*	6"-12"	July-Oct		Full sun Partial shade	Front of borders, ground cover, rock gardens
Bleeding Heart (see Dicentra)						
Campanula (Carpathian Harebell)	*C. carpatica* 'Blue Carpet' 'China Doll'	6"-12"	June-Aug	Blue-lilac White Purple	Full sun Partial shade	Borders or rock gardens
Campanula (Danesblood) (Clustered Bellflower)	*C. glomerata*	1'-1 1/2'	June-Aug	White Blue Purple	Full sun Partial shade	Borders, bedding between shrubs, cut flowers
Campanula (Canterbury Bells)	*C. medium* 'Cup and Saucer'	2'-4'	June-Aug	White Pink Blue Mauve	Full sun Partial shade	Borders, isolated clumps, balconies
Campanula (Peach Bells)	*C. persicifolia*	2'-3'	June-Aug	White Blue	Full sun Partial shade	Borders
Canterbury Bells (see Campanula medium)						
Carnation (see *Dianthus caryophyllus*)						
Cerastium (Snow-in-Summer)	*C. tomentosum* 'Columnae' 'Yoyo'	6"	May-June	White	Full sun	Evergreen, ground cover, dry stone walls, edging
Ceratostigma (Plumbago)	*C. plumbaginoldes*	8"-10"	July-Sept	Dark blue	Full sun Partial shade	Rock gardens, ground cover

Table 1. (cont'd)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Cheiranthus (Wallflower)	*C. cheiri*	9"-30"	March-May	White Yellow Brown Red Pink Purple	Full sun	Balconies, terraces, mixed borders, flower beds, banks rockeries, slopes
Chive (see Allium)						
Chrysanthemum (Shasta Daisy)	*Chrysanthemum x supermum* 'Alaska' 'Esther Read' 'Little Miss muffet' 'Marconi' 'Snowcap'	2'-4'	June-Oct.	White	Full sun Partial shade	Cut flowers, borders
Columbine (see Aquilegia)						
Convallaria (Lily-of-the-Valley)	*C. majalis*	6"-12"	May	White	Full sun Partial shade	Ground cover, cut flowers
Coral Bells (See Heuchera)						
Crocus & hybrids	*Crocus* spp.	2"-6"	Early spring	Golden yellow Blue Lavender Purple White Purple striped	Full sun to partial shade	Excellent for early color; Large-flowered "Dutch hybrids" bloom later than most spring-flowering types
Crocus (Autumn)	*Colchicum autumnale*	4"-6"	Early spring	Lavender-pink Rose White	Full sun to partial shade	Foliage grows in spring, then dies, flowers appear in fall without foliage
Coreopsis (Tickseed)	*C. lanceolata* 'Baby Sun' 'Brown Eyes' 'Goldfink' 'Mayfield Giant' 'Sunburst' *C. rosea* *C. verticillata* 'Moonbeam' 'Zagreb'	2'-3'	June-July	Yellow Yellow chestnut	Full sun	Borders, cut flowers
Creepin Jennie (see Lysimachia)						
Daffodil (see Narcissus)						
Daisy, English (see Bellis)						
Daisy, Gloriosa (see Rudbeckia)						
Daisy, Painted (see Pyrethrum)						
Daisy, Shasta (see Chrysanthemum)						
Daylily (see Hemeracallis)						
Delphinium (Larkspur)	*D. elatum*	3'-6'	June-July	Many	Full sun	Background accent, cut flowers

Table 1. (cont'd)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Dianthus	*D. barbatus*	4"-6"	May-Aug	White Pink Scarlet	Full sun	Cut flowers, balconies, terraces, borders, rockeries, flower beds
Dianthus (Carnation) (Clove Pink) (Divine Flower)	*D. caryophyllus* 'Chabaud's Giant Improved' 'Dwarf Fragrance Mixed' 'Enfant de Nice Mixed' 'Juliet' 'Oriental Hybric Mixed' 'Spotti' 'Tiny Rubies'	1'-2'	June-Aug	White Pink Red Purple Yellow Apricot Orange	Full sun	Cut flowers, flower beds, pot plants, borders
Dianthus (Pinks)	*D. chinensis*	6"-12"	Summer-fall	Red White Pink	Full sun Partial shade	Edging, cut flowers bedding
Dianthus (Maiden Pink) (Meadow Pink) (Spink)	*D. deltoides* 'Brilliant'	4"-12"	May-Aug	White Pink Red	Full sun	Rock gardens, border plants
Dicentra (Bleeding Heart)	*Dicentra* spp.	2'-3'	May-June	Red and white	Partial shade	Cut flowers, shaded borders
Digitalis (Common Foxglove) (Fairy Glove) (Fingerflower) (Purple Foxglove)	*D. purpurea* 'Leopard Foxglove'	2'-5'	May-July	Purple and White	Full sun Partial shade	Borders, cut flowers
Doronicum	*D. cordatum* 'Finesse' 'Madam Mason'	2'	April-May	Yellow	Full sun Partial shade	Front or middle perennial borders, cut flowers
Echinops (Glove Thistle)	*E. exaltatus* 'Tapglow Blue'	3'-5'	July-Sept	Blue	Full sun	Cut and dried flowers back of borders
Erigeron (Gleabane)	*E. speciosus*	1'-2'	June-July	Blue	Full sun	Cut flowers, rock gardens, borders
Euphorbia	*E. myrsinites*	8"-10"	March-May	Yellow	Full sun	Border plants, cut flowers, rock gardens
Euphorbia (Cushion Spurge)	*E. polychroma* (epithymoides)	11/2'	March-May	Yellow	Full sun	Border plants, cut flowers
Festuca (Blue Fescue)	*F. ovina glauca*	6"-10"			Full sun Partial shade	Edging, banks, ground cover
Flax (Golden Flax)	*Linum flavum*	1'-2'	June-Aug	Golden yellow	Full sun	Rock gardens
Forget-Me-Not (see Anchusa)						
Foxglove, Common (see Digitalis)						
Fritillaria (Crown Imperial)	*F. imperialis*	2'-3'	Spring	Red Yellow Orange	Sun or light shade	A very showy old-fashioned plant, but odor may be offensive

Table 1. (cont'd)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Fritillaria (Checkered Lily or Guinea-Hen Flower)	*F. meleagris*	8"-12"	Spring	Checkered purple White	Sun or light shade	Fragile appearance; makes an interesting rock garden plant
Fritillaria (Persian Fritillary)	*F. persica*	10"-30"	Spring	Maroon Purple White	Full sun	Flowers have a slight skunk odor
Gaillardia (Indian Blanket)	*G. pulchella* 'Baby Cole'	1'-2'	Summer Fall	Yellow Orange Scarlet	Full sun	Cut flowers, window boxes, planters
Geranium (Cranesbill)	*Geranium* spp. 'Biokova' 'Johnson's Blue'	1'-2'	May-Sept	Blue Purple	Full sun Partial shade	Rock gardens, perennial gardens
Geum	*Geum* spp.	2'-21/2'	May-Aug	Scarlet Orange	Full sun	Groupings in perennial borders, cut flowers
Glory-of-the-Snow	*Chinonodoxa luciliae*	3"-6"	Early spring	Blue Pale pink White Yellow	Full sun	Rock gardens, borders and edgings
Gypsophila (Baby's Breath)	*Gypsophila* spp.	1'-3'	June-July	Rose Purple White Pink	Full sun	Borders, dry flowers, rock gardens
Helianthemum (RockRose) (Sun Rose)	*H. nummularium*	1'	June-July	Yellow Rose Red and crimson White	Full sun	Rock gardens, slopes and pockets, crazy paving
Hemerocallis (Daylily)	*Hemerocallis* spp.	2'-4'	Spring Summer Fall	Many	Full sun Partial shade	Foundation plants, borders
Hen-and-Chickens (see Sempervivum)						
Heuchera (Coral Bells) (Alum Root)	*H. sanguinea* 'Bressingham hybids' 'Charteuse' 'Chatterbox' 'June Bride' 'Matin Bells' 'Pluie de Feu' (Rain of fire) 'White Cloud'	1'-21/2'	May-July	Red Pink White	Full sun Partial shade	Rockeries, borders
Hollyhock (see Alcea)						
Hosta (Plantain Lily)	*Hosta* spp.	1'-2'	July-Sept	White Lavender Lilac	Full sun Partial shade Full shade	Borders, rock gardens, masses
Hyacinth (Armenian Grape)	*Muscari armeniacum*	6"-8"	Early spring	Blue	Full sun to partial shade	Multiplies rapidly, excellent for edging or indoor forcing, fragrant
Hyacinth (Grape Hyacinth)	*Muscari botryoides*	6"-8"	Early spring	Blue White	Full sun or partial shade	Produces clusters of tiny flowers, double flowers hold color longer

Table 1. (cont'd)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Hypericum (Aaron's Beard) (Rose of Sharon) (St. John's Wort)	*H. calycinum*	1'-1 1/2'	June-Sept	Yellow	Full sun Partial shade	Shady slopes, banks, flowerbeds, borders, ground cover
Iberis (Evergreen Candytuft) (Edging Candytuft)	*I. sempervirens* 'Autumn Snow" 'Little Gem' 'Purity' 'Snowflake' 'Snowmantle'	6"-1'	April-May	White	Full sun	Rock gardens, edging
Incarvillea (Hardy Gloxinia)	*Incarvillea* spp.	1'	June-July	Red Pink	Full sun	Perennial gardens, rock gardens
Iris (True-Bearded) (Siberian) (Japanese)	200+ species and many cultivars	4"-48"	Spring to fall, most May to June, some rebloom	Wide range	Full sun	Beyond flowers, leaves provide texture, contrast of colors and combinations
Kniphofia (Red-Hot Poker) (TorchLlily) (Tritoma) (Poker Plant)	*K. uvaria*	2'-4'	May-Sept	Red Yellow	Full sun	Borders, cut flowers
Lamb's ear (see Betonica)						
Lamium (Spotted Dead Nettle)	*L. maculatum* 'White Nancy'	1'	April-Sept	Purple-red White	Partial shade Full shade	Shaded perennial borders, rock gardens, summer filler
Lavandula (Sweet Lavender)	*Lavandula* spp. 'Hidcote' 'Munstead'	1'-3'	June-Sept	Purple	Full sun	Borders, rockeries, cut flowers, evergreen
Liatris (Gayfeather) (Blazing Star)	*Liatris* spp. 'Kobold'	1 1/2'-5'	July-Oct	White Purple Pink	Full sun Partial sun	Cutting, drying, borders
Lily (Asiatic Hybrids)	Genus *Lilium* has 100+ species and many cultivars	2'-7'	June to July	Wide range	Full sun to partial shade	Accent plants
Lily (Trumpets)	Genus *Lilium* has 100+ species and many cultivars	2'-7'	July	Wide range	Full sun to partial shade	Accent plants
Lily (Surelians)	Genus *Lilium* has 100+ species and many cultivars	2'-7'	July	Wide range	Full sun to partial shade	Accent plants
Lily (Oriental Hybrids)	Genus *Lilium* has 100+ species and many cultivars	2'-7'	July to Aug	Wide range	Full sun to partial shade	Accent plants
Lily-of-the-Valley (see Convallaria)						
Limonium (Sea Lavender) (Statice)	*L. sinatum*	1 1/2'-2'	June-Aug	White Yellow Blue Red	Full sun	Flowerbeds, borders, small clumps, rockeries, cut and dried flowers

Table 1. (cont'd)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Liriope	*Liriope* spp.	10"-15"	Aug-Sept	Purple	Full sun Partial shade Full shade	Evergreen, borders, perennial gardens, rock gardens
Lupine (Lupin)	*L. polyphyllus* George Russell hybrids	2 1/2'-5'	May-July	Blue Purple Reddish purple Yellow	Full sun Partial shade	Cut flowers, borders
Lychnis (Maltese Cross) (Jerusalem Cross)	*L. chalcedonica*	2'-3'	June-July	Scarlet	Full sun	Small groupings in borders
Lysimachia (Creeping Jennie) (Moneywort) (Creeping Charlie)	*L. nummularia*	6"-8"	June-Nov	Yellow	Full sun Partial shade Full shade	Shaded slopes and banks, walls, hanging baskets, bag gardens, submerged aquarium plant
Maltese Cross (see Lychnis)						
Monarda (Wild Bergamot)	*M. fistulosa* 'Gardenview Scarlet'	to 3'	June-Aug	Lilac Purple White	Full sun Partial shade	Borders
Narcissus (Daffodil) (Jonquil)	spp. & hybrids	3"-14"	Early to midspring	Yellow White Pink (Cups: yellow, white, pink, orange, or nearly red)	Full sun or light shade	Borders, shrub beds, or naturalized, good for cut flowers
Ostrich Fern (see Pteretis)						
Pachysandra (Japanese Pachysandra)	*P. terminalis* 'Variegata' (Silver edge)	6"-8"	May	White	Partial shade Full shade	Ground cover, slopes, level ground, beneath trees
Paeonia (Peony)	*P. lactiflora*	3'	May-June	Many	Full sun Partial shade	Accent, cut flowers
Papaver (Iceland Poppy)	*P. nudicaule*	2'-4'	May-June	Many	Full sun Partial shade	Borders, cut flowers
Papaver (Oriental Poppy)	*P. orientale*	2'-4'	May-June	Many	Full sun	Borders, cut flowers
Peony (see Paeonia)						
Phlox, Creeping	*P. subulata*	6"-10"	April-June	White Pink Salmon Purple	Full sun Partial shade	Edging, bedding, rock gardens
Phlox, Tall (Summer Phlox) (Garden Phlox)	*P. paniculata* 'Symons-Jeune'	2'-3'	July-Sept	White Pink Red Blue Purple	Full sun Partial shade	Borders
Physostegia	*P. virginiana* 'Bouquet Rose' 'Vivid' 'Summer Snow'	2'-3'	July-Sept	Rose- purple White	Full sun Partial shade	Cut flowers, back of wild flower gardens borders, informal wildflower gardens

Table 1. (cont'd)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Platycodon (Chinese Bellflower) (Balloon Flower) (Japanese Bellflower)	*P. grandiflorum* 'Apoyama' 'Shell Pink'	2'	July-Sept	Blue Pink White	Full sun Partial shade	Cutting, rock gardens, borders
Plumbago (see Ceratostigma)						
Polemonium (Jacob's Ladder)	*P. caeruleum* 'Blue Pearl'	1 1/2'	May-June	Blue	Full sun Partial shade	Rock gardens, foreground of perennial borders
Poppy, Iceland (see Papaver nudicaule)						
Poppy, Oriental (see Papaver orientale)						
Potentilla	*P. verna*	4"-6"	May-Oct	Yellow	Full sun Partial shade	Ground cover
Primrose, Polyanthus	*Primula x polyantha* 'Colossea Hybrids' 'Pacific Giants'	6"-12"	April-June	Many	Partial shade	Shaded areas in perennial borders, shaded streams
Pleretis (Ostrich Fern)	*P. modulosa*	3'-4'	Foliage		Partial shade Full shade	North exposures, under trees or any place where light is not abundant
Pyrethrum (Painted Daisy)	*Pyrethrum* spp.	1 1/2'-2'	June-July	Pink Red White	Full sun Partial shade	Rock gardens, borders, naturalizing, cut flowers
Red-hot poker (see Knipofia)						
Rudbeckia (Gloriosa Daisy)	*R. hirta pulcherrima* 'Gloriosa Daisy' (*Rudbeckia x hybrida*) 'Gloriosa Double Daisy' 'Gloriosa Irish Eyes' 'Goldstrum' 'Marmalade' 'Rustic Colors'	2-3"	July-Sept	Golden yellow Brown	Full sun Partial shade	Cutting, background
Santolina (Lavender Cotton)	*S. chamaecy-parissus*	1'	June	Yellow	Full sun	Evergreen, rock gardens, low hedge, carpet bedding
Sapanaria (Bouncing Bet) (Soapwort)	*S. officinalis*	1'	July-Sept	Pink White	Full sun Partial shade	Wild gardens, rough corners
Saxifraga	*Saxifraga* spp.	3"-18"	June-Aug	Yellow White Red Pink Purple	Partial shade	Rock gardens, borders, edging, potted plants
Scabiosa (Caucasian Scabious) (Pincushion Flower)	*S. caucasian* 'Butterfly Blue' 'Pink Mist'	2'	June-Sept	Blue White Mauve	Full sun	Borders, flowerbeds, cut flowers
Sea lavender (see Limonium)						

Table 1. (cont'd)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Sedum (Showy Stonecrop) (Live Forever)	*S. spectabile* 'Autumn Joy' 'Brilliant' 'Indian Chief' 'Meteor' 'Star Dust' 'Variegatum'	1 1/2'-2'	Aug-Oct	Pink Red White	Full shade Partial shade	Rock gardens, borders
Sedum	*Sedum* spp. 'Dragon's Blood'	6"	Aug-Oct	Red	Full sun Partial shade	Rock gardens, borders
Sempervivum (Hen-and-Chickens) (Old-Man-and-Woman) (Houseleeks) (St. Patrick's Cabbage)	*S. tectorum*	6"-30"	July	Purple-red	Full sun	Rock gardens, dry walls, edging, front of perennial borders, carpet bedding, containers
Snowdrop (Giant snowdrop)	*Galanthus nivalis*	6"-9"	Spring	White	Full sun	Good for borders and rock gardens
Snowdrop (Common Snowdrop)	*Galanthus nivalis*	4"-6"	Early spring	White	Partial shade	One of the earliest spring bulbs for rock gardens, borders, naturalizing, easy to grow, increases rapidlly
Snow-in-Summer (see Cerastium)						
Stachys (see Betonica)						
Statice (see Armeria or Limonium)						
Sweet Lavender (see Lavandula)						
Sweet William (see *Dianthus barbatus*)						
Teucrium (American Germander)	*T. canadense*	6"	June-July	Rose	Full sun	Edging, rock gardens
Teucrium (Germander)	*T. chamaedrys*	4"-12"	June-July	Purple	Full sun	Edging, rock gardens, hedges
Thymus (Thyme)	*T. serpyllum*	3"-6"	June-July	Purple White Red	Full sun	Rock gardens, herb gardens, stone walls
Tradescantia (Virginia Spiderwort) (Widow's Tears)	*T. virginiana* 'Purple Dome'	1 1/2'-2'	June-Sept	White	Full sun Pink Red Partial shade	Borders, foundations
Tritoma (see Kniphofia)						
Trollius (Globe Flower)	*T. europaeus*	1'-2'	May-July	Lemon Orange	Shade	Borders
Tulip	*Tulipa* spp. & hybrids	3"-30"	Spring	All colors except true blue	Full sun	Variety of colors, shapes, blooming times for all uses, may use annuals to cover ground above bulbs in summer

Table 1. (cont'd)

Common name	Scientific name	Height	Bloom time	Flower color	Light needed	Landscape use
Valeriana	*V. officinalis* 'Rubra'	3'-5'	June-July	Pink White Red Purple	Full sun Partial shade	Perennial gardens, background
Veronica	*Veronica* spp. 'Red Fox' 'Sunny Border Blue'	1 1/2'	June-Aug.	Blue Pink Red White	Full sun	Borders, cut flowers, rock gardens
Vinca (Lesser Periwinkle) (Myrtle)	*Vinca minor*	6"-8"	March-May	Blue-purple	Partial shade Full shade	Ground cover in flower beds or rockeries, shrubberies
Wall Flower (see Cheiranthus)						
Yarrow (see Achillea)						

Further Reading

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For More Information

Hardy Plant Society of Oregon, P.O. Box 5090, Oregon City, OR 97045

Northwest Perennial Alliance, P.O. Box 45574, University Station, Seattle, WA 98145-0574.

Perennial Plant Association, Attn: Dr. Steven M. Still, 3383 Schirtzinger Road, Hilliard, OH 43026.

Perennial Study Group, Arboretum Foundation, Washington Park Arboretum, University of Washington, Box 358010, Seattle, WA 98195-8010.

Booklets and Pamphlets

University of Idaho Extension

PNW 550 Encouraging Beneficial Insects in Your Garden

PNW 500 Plant Materials for Landscaping

PNW 164 Propagating from Bulbs, Corms, Tubers, Rhizomes, and Tuberous Roots and Stems

PNW 151 Propagating Herbaceous Plants from Cuttings

PNW 170 Propagating Plants from Seed

CIS 858 Using Bark and Sawdust for Mulches, Soil Amendments, and Potting Mixes

CIS 1062 Starting a Home Lawn

CIS 1063 Thatch Prevention and Control in Home Lawns

PNW 299 Turfgrass Seedings: Recommendations for the Pacific Northwest

CIS 888 Weed Control in Lawns

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Chapter 20

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Chapter 20
Principles of Vegetable Culture

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Few things in life are more rewarding than savoring a meal of home-grown vegetables. Vegetable gardening can be enormously satisfying. However, there can be no argument that it also is complex and fraught with problems, requires hard work, and involves many personal decisions.

The most successful vegetable gardeners understand basic concepts of botany, plant growth and development, plant health, irrigation, soil fertility, and pest and disease control. Many of these principles are covered elsewhere in the *Idaho Master Gardener Program Handbook*. Detailed information about specific vegetable crops is found in the next chapter. Many good books about vegetable gardening are also available.

PLANNING THE GARDEN

For some gardeners, planning a garden is an interesting and satisfying activity. If this is you, have fun with the process and take all the time you want. Get out the gardening books during the deep, dark months of winter, explore options for new crops and varieties, make a graph-paper map, and dream about summer harvests.

For others, planning seems to get in the way of accomplishment. If this describes you, cut the planning to a bare minimum and get on with buying seed. However, some planning is essential to success in vegetable gardening.

Planning can be broken into two phases: garden design and annual planning.

Garden design

Some decisions need to be made early in the planning process. A good approach is to take a few minutes to answer some fundamental questions. Here are a few (but surely not all) of the questions to consider.

How much time do I have for vegetable gardening?

This question may seem trivial, but it will affect everything else you do. Planting a garden and discovering you lack the time and resources to care for it properly leads to frustration. If you have only a few minutes a day to dedicate to gardening, plan a small garden that contains two or three of your favorite vegetables. You may opt to grow plants on your porch in pots or containers. At the other extreme, if you have plenty of time and energy, the garden can be more extravagant and include hobby activities such as testing unique varieties or growing unusual or marginally adapted crops. Or, if gardening is a life-sustaining activity, the scale of production may be quite large and your plans should be based on food storage potential.

What do I like to eat?

Plan to produce only crops that you and your family like and will prepare and consume. It's a waste of time and resources to grow produce that serves only as compost. Determine which vegetables you will consume fresh and which will be preserved and stored. Consider making room to experiment with small amounts of new crops or varieties. Over time, you may find a new favorite.

How much room do I have for vegetable gardening?

Sometimes the limitations for producing vegetables have less to do with time than with space. In this case, prioritize your goals and fit in only those crops you consider most valuable (your favorites). Plant crops that produce large quantities in limited space, such as tomatoes or cucumbers. Crops such as corn and squash require a lot of space; place them lower on the priority list.

Where should I locate my garden?

This can be a difficult question to answer, as it is influenced by personal preference, impact on the

appearance of the landscape, plant needs, and occasionally property ordinances. Public visibility creates a need for more intense design and maintenance. Selecting a warm microclimate, e.g., next to a south-facing fence or wall, may make it possible to grow crops, such as melons, that are otherwise marginally adapted.

Regardless of all other considerations, one requirement must always be met: sunlight. Almost all vegetable crops require full sunlight to grow and produce properly. Many books say that a vegetable garden should get at least 6 hours of sunlight per day. The origin of this recommendation is unknown, but it probably did not come from an experienced gardener. To maximize production and quality, a garden needs all-day sun, with the possible exception of an hour or two of shade at dawn and dusk; the more sunlight, the better.

Property features can place extreme limitations on garden placement. If options are available, here are a few tips to consider:

- Avoid placing the garden in a low swale, at the base of a hill, or at the foot of a slope bordered by a solid fence. Frost settles in these places because cold air naturally drains toward the lowest spot in the yard.
- Avoid windy locations (hard to do in Idaho!). If you must plant in a windy spot, build or plant a windbreak.
- Avoid planting near trees and shrubs that will compete for sunlight, nutrients, and water. Stay 10 to 20 feet outside tree drip lines (an imaginary line on the ground at the edge of the tree canopy), if possible (figure 1).
- Choose a spot near your home so it is convenient to work in the garden when you have a few minutes.
- Locate the garden near a good and easily accessible supply of water.
- Avoid contaminated areas. Water runoff from roads, sidewalks, or driveways can contaminate the soil with salt, herbicides, or soil sterilants. Do not plant near chemical manufacturing or storage facilities without investigating safety issues. Sites where lead-painted buildings once stood may contain toxic amounts of soil lead. If you are unsure about your chosen location, check the lead (and other heavy metals) content by having the soil or leafy vegetable tissue analyzed.

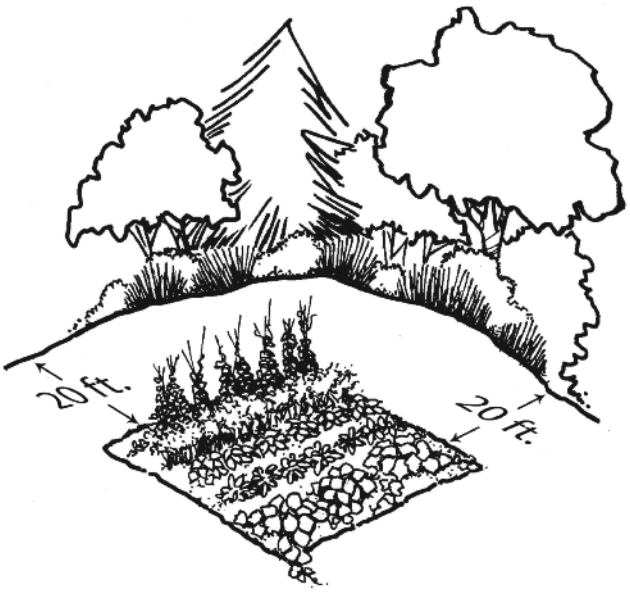


Figure 1. Locate vegetable gardens in full sun and at least 20 feet from the drip line of trees and shrubs to avoid competing roots.

What type of vegetable production system should I use?

There are as many ways to lay out a vegetable garden as there are gardeners (figure 2). Many people use some form of the traditional victory garden (straight, wide rows). Others use small beds, raised beds, trellis and stake systems, or containers. Part of this decision is based on garden size. Large gardens are usually best planted in rows so that tillers and other equipment can reduce the need for hand labor. Small gardens usually work best when laid out as intensively managed beds in order to maximize production in a limited space. Intensive production systems can also reduce the amount of work needed for weed and pest control. Common production systems are described later in this chapter.

Where should I place perennial beds?

Consider this question early in the design process. Some vegetable, such as asparagus, rhubarb, chives, and many herbs, are perennial; they regrow each spring and are a permanent part of the garden. Locate these crops where they will not interfere with annual garden operations. Perennials are typically grouped along one side or in one corner of the garden. Another technique is to use them as landscape features outside of the annually managed portion of the garden.

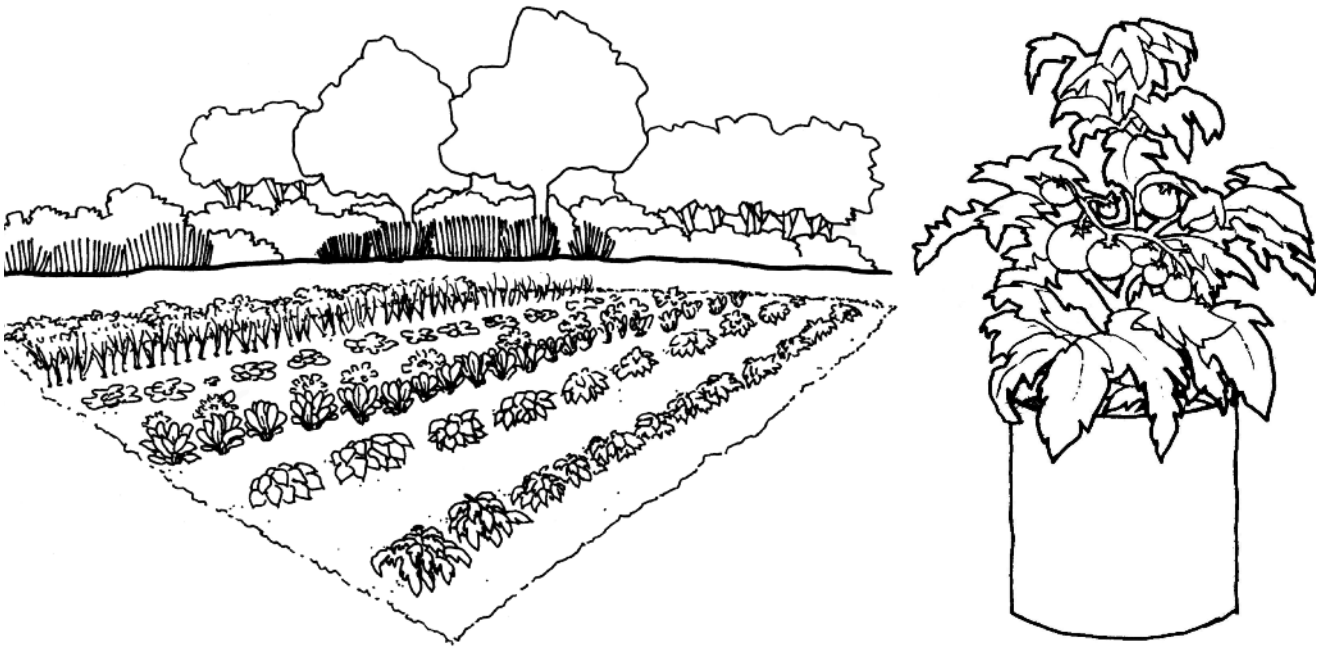


Figure 2. Productive vegetable garden designs range from the traditional open rows of a "victory garden" to space-saving containers.

Annual planning

Determination of gardening objectives, garden size, and production system needs to be done only once, although you probably will modify your plan in subsequent years. Good gardeners are never happy with the status quo. However, some planning must be done every year in order to maximize crop yield and quality.

Choose the best vegetable varieties

Varieties differ not only in appearance and flavor, but also in earliness, adaptation, and many other characteristics that influence growth in a specific climate. In the short-season climates typical of much of Idaho, choosing the right varieties is critical to success. Information provided on seed packets, such as days to harvest and general descriptions of best production conditions, are typically inadequate for determining suitability, given Idaho's propensity for frost, cool nights, intense sunshine, low humidity, and/or alkaline soils. Obtain information about the best varieties from experienced gardeners, Master Gardener volunteers, local nurserymen, and county educators.

Place and rotate the crops

Deciding where to plant individual crops each year can be frustrating. However, these decisions are critical. Crop rotation, the practice of changing the location of crops to avoid disease and nutritional problems, is a sound agricultural principle. Many vegetable crops become weak and unproductive if they are planted in the same place every year.

You can simplify these decisions by taking the time to group plants into blocks based on genetic relatedness and growth habit. Plants in the same family often have the same needs and problems. Each year, keep the crops in their established blocks and simply rotate the blocks through the available space (figure 3). If done properly, each block of similar plants should end up in the same plot of soil once every 3 to 5 years.

Rotation to prevent disease problems is more important for some crops than others. It is critical for the solanaceous crops (potatoes, tomatoes, peppers, eggplants, etc.), cucurbits (cucumbers, melons, squash, pumpkins, etc.), and cole crops (cabbage, broccoli, cauliflower, brussels sprouts, etc.).

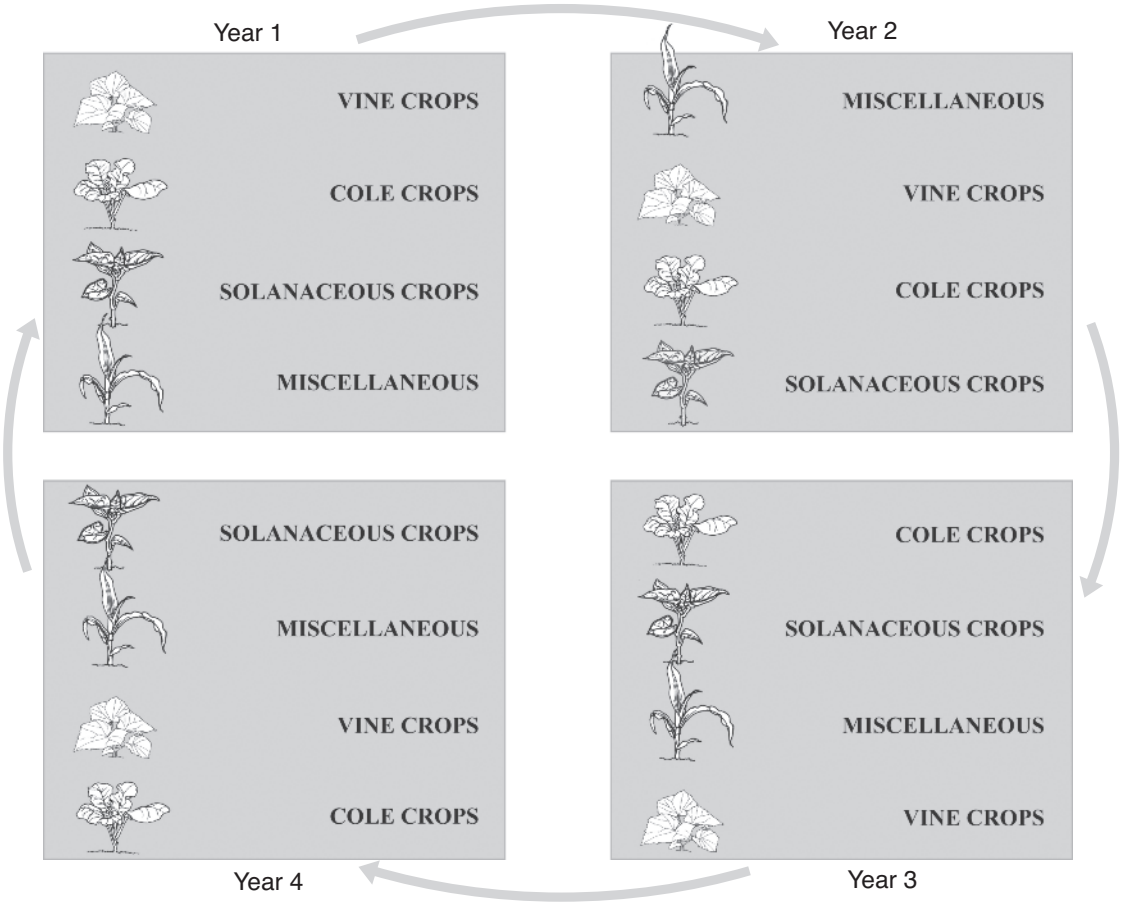


Figure 3. Example of crop rotation by grouping crops with similar growing requirements. Each shadowed square represents the garden in a given year. Categories within the squares represent crop groups that are rotated within the garden space. Cole crops include broccoli, cauliflower, cabbage, brussels sprouts, and all of the kales and mustards. Vine crops include melons, cucumbers, squash, and pumpkins. Solanaceous crops include tomatoes, potatoes, peppers, and eggplant.

Take into account plant height, spread, and growth habit. Don't plant tall or aggressive plants where they will overgrow or shade smaller plants.

VEGETABLE PRODUCTION SYSTEMS

Vegetable gardening systems fall into two major categories: (1) low-intensity victory gardens planted in wide rows or hills, and (2) intensive gardening systems planted in beds or containers. Victory garden layouts are best used in large gardens (more than 500 square feet) where simplicity of operations and use of motorized equipment is required. If space and/or time is limited, intensive garden designs are best. The production systems described here are only a sampling of the possibilities, but the concepts apply to most garden systems.

Victory garden designs

The term victory garden originated during World War II and was used to describe a vegetable gardening system consisting of wide, straight rows running the length of the garden (figure 4). It is the simplest design for a vegetable garden and the best method when large amounts of produce are needed for preservation, storage, or local sale. Any vegetable can be produced in a victory garden arrangement, but it is especially good for crops needed in large quantities, such as corn, peas, beans, potatoes, and broccoli.

There are many adaptations to the single-row planting design typical of the victory garden. The following are some common planting arrangements:

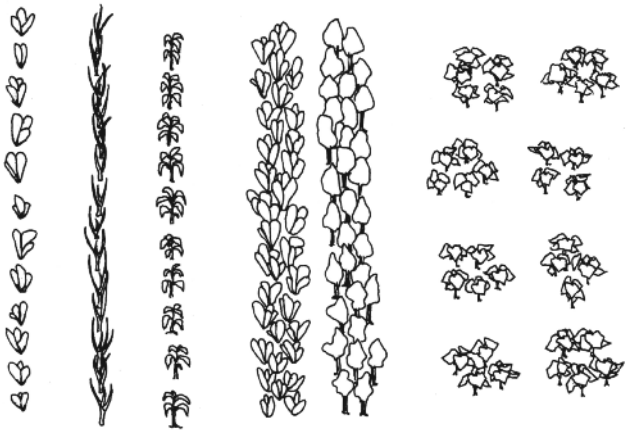


Figure 4. Possible row arrangements within a standard victory garden design.

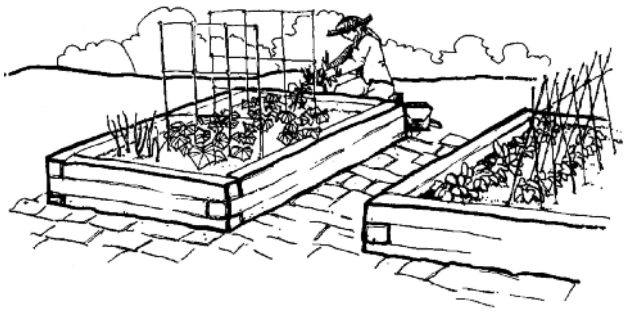


Figure 5. Example of a raised bed intensive gardening system.

- **Row planting**. This arrangement consists of long, straight rows, usually 2 or more feet apart, with a single line of plants in each row (figure 4, left). A string stretched between stakes or homemade row markers can provide a guide for straight rows. Use a hoe handle, a furrow hoe, or a grub hoe to make a furrow of the appropriate depth. Space the seed uniformly and at a distance suitable for the crop.
- **Broadcast row planting**. In the victory garden, broadcast planting usually involves placing seed in rows arranged as wide bands rather than single-wide plants (figure 4, center). Many crops, especially root crops such as carrots, radishes, and beets, produce higher quality vegetables when planted this way. Sow seed evenly across the planting band and rake it in. Lightly cover and press the soil over the seeds.
- **Hill planting**. Larger vegetables, such as melons, squash, corn, and cucumbers, may be planted in hills (figure 4, right). The hills can be arranged in extra-wide rows to facilitate cultivation. Distance between hills is based on recommendations for individual crops. Mound soil a few inches high and a foot or so in diameter and plant in the center of the mound. Plant four to six seeds per hill, firming the soil well.

Intensive garden designs

Intensive garden designs require considerable effort to plan and install, but are relatively easy to maintain. Plans should include dimensions, construction materials, soil media, variety choice, and plant arrangement. Proven intensive garden designs include raised beds, vertical gardens, and container gardens. When combined with production techniques such as interplanting, succession planting, relay planting, and edible landscaping, these garden designs maximize the use of limited space.

Raised beds

The typical "raised bed" garden consists of defined borders of wood or masonry filled with heavily amended soil to a level above the surrounding ground (figure 5). Raising the bed above ground level accomplishes two very important things: it improves drainage and it allows the soil to warm up faster in the spring. Both factors can improve plant growth and production potential.

The actual garden design and the selection of border materials are personal choices. Typical beds are raised 6 to 8 inches, but they may be as much as 3 feet above grade. Borders may be permanent structures (made from concrete or other immovable materials) or temporary. Wood landscape timbers are a common choice. Redwood or cedar timbers will minimize deterioration due to constant exposure to moisture. Pressure-treated landscape timbers are commonly available. There is no evidence that the new generation of treated timbers are toxic or harmful to plants or consumers, but older timbers or railroad ties were commonly treated with creosote or pentachlorophenol (penta), both toxic to plants and people. If unsure, you may want to use only untreated wood.

There are no standard dimensions for raised bed gardens. Typically they are narrow enough to allow the gardener to reach to the center of the bed without stepping on the soil. The length is usually a function of the location; beds may be only a few feet long or stretch across the yard.

Soil preparation is an important aspect of raised bed gardening. The final soil mix commonly consists of one part native soil and one part compost or aged organic matter. Many other choices for soil components exist; for example, manure, peat, sand, vermiculite, or perlite may be added in various quantities. The simplest method for preparing the soil is to remove the top 12 inches of soil from the completed bed, place it in a pile, mix the pile with an equal amount of organic matter, and shovel the mixture back into the bed. At this point, the bed will be ready for plants.

Table 1. Plant spacing guide for raised bed or other intensive vegetable garden designs.

Plant	Spacing[a] (inches)	Plant	Spacing[a] (inches)
Asparagus	15 to 18	Leeks	3 to 6
Beans, bush	4 to 6	Lettuce, head	10 to 12
Beans, lima	4 to 6	Lettuce, leaf	4 to 6
Beans, pole	6 to 12	Melons	18 to 24
Beets	2 to 4	Mustard	6 to 9
Broccoli	12 to 18	Okra	12 to 18
Brussels sprouts	15 to 18	Onions	2 to 4
Cabbage	15 to 18	Peas	2 to 4
Carrots	2 to 3	Potatoes	10 to 12
Cauliflower	15 to 18	Peppers	12 to 15
Chinese cabbage	10 to 12	Pumpkins	12 to 36
Cucumbers	12 to 18	Radishes	2 to 3
Chard, Swiss	6 to 9	Rutabaga	4 to 6
Collards	12 to 15	Spinach	4 to 6
Eggplants	18 to 24	Squash, summer	18 to 24
Endive	15 to 18	Squash, winter	24 to 36
Kale	15 to 18	Tomatoes	18 to 24
Kohlrabi	6 to 9	Turnips	4 to 6

Note: To determine spacing for interplanting, add the inches for the two crops to be planted together, and divide the sum by two. For example, if radishes are planted next to beans: 2 inches + 4 inches = 6 inches. Then, 6 inches ÷ 2 = 3 inches. Plant the radishes 3 inches from the beans.

The use of miniature varieties or vertical gardening techniques may allow closer spacing and increase the square-foot productivity.

[a] Arrange plants in square grid patterns. The indicated spacing is the distance to other plants in all directions. These recommendations for intensive gardening typically are for slightly closer spacing than the spacings suggested in the next chapter, which are based on recommendations for a traditional victory garden.

Plant arrangement should optimize the use of the limited space. Give each plant a square space large enough for it to grow properly. The goal is to space plants equidistant from one another on all sides so that, at maturity, plant leaves touch or slightly overlap. Spacing recommendations for raised beds are summarized in table 1. The use of dwarf or bush-type varieties will minimize space needed for many crops, such as beans, cucumbers, tomatoes, and squash.

Vertical gardening

The use of trellises, nets, strings, cages, or poles to hold plants upright and limit horizontal spread constitutes vertical gardening (figure 6). Vining and sprawling plants, such as cucumbers, tomatoes, melons, and pole beans, are obvious candidates for this type of gardening. Tomatoes, for example, require about 10 square feet per plant when unstaked, but can be grown in 1 square foot of space if supported and trained upward. Vertical gardening can be used in victory gardens, raised beds, containers, or by itself.

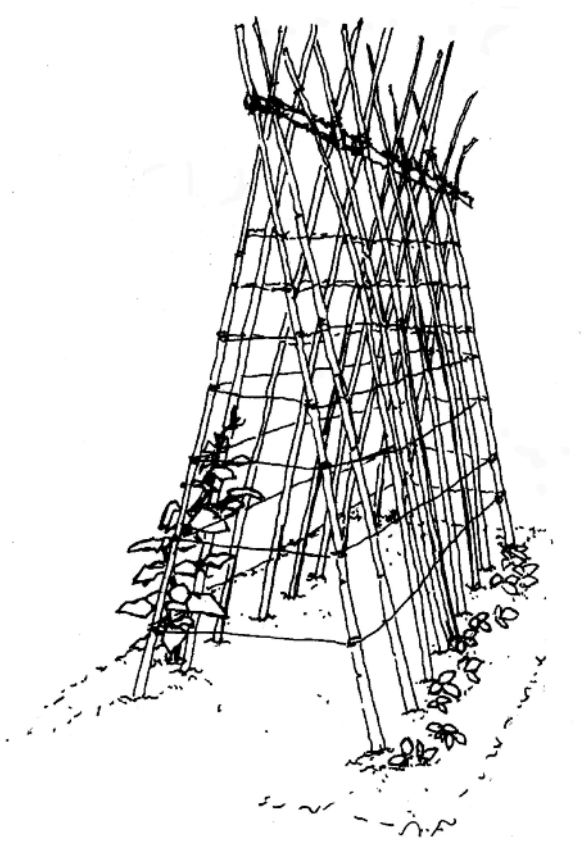


Figure 6. Example of a structure used for vertical vegetable gardening.

Supports for plants can be simple or extravagant. They can take advantage of existing structures, such as buildings or fences, or can stand alone. The height of the support depends on the crop. Shorter plants, such as tomatoes, cucumbers, and pole beans, grow to a height of 5 to 6 feet. Squash may need 15 to 20 feet of vertical space or a structure that will allow some horizontal growth at the top (e.g., a high tunnel). In Korea, gardeners plant squash and other vine crops next to the walls of buildings, allowing them to climb a trellis and eventually set fruit on the roof.

Vertical gardening saves considerable space but is labor-intensive. Staking, tying, pruning, and training new growth upward takes time. Most plants do not climb naturally, so simply planting next to a vertical structure will not necessarily convince plants to reach skyward.

Because vertically growing plants are more exposed, they dry out faster and may need to be watered more frequently than those allowed to spread over the ground. A vertical planting will cast a shadow, so be sure to locate the structures where they will not shade non-vertical parts of the garden.

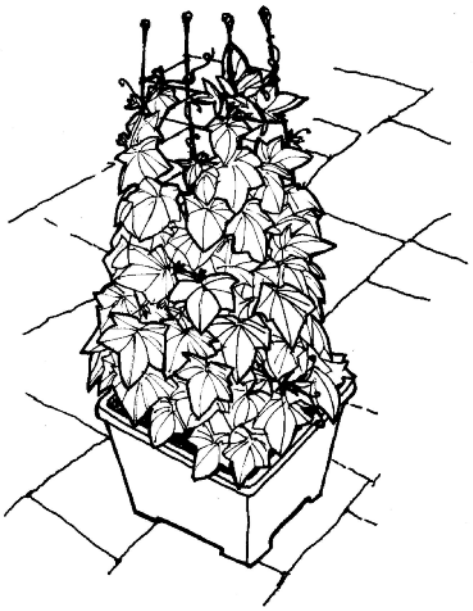


Figure 7. The ultimate in intensive vegetable gardening is container gardening. Tomatoes, peppers, cucumbers, and many other crops can be grown in containers.

Container gardening

If you don't have yard space for a vegetable garden, or if your garden is too small to produce everything you want, consider raising vegetables in containers (figure 7). A window sill, patio, balcony, or doorstep can provide sufficient space for a productive container garden. Container gardens can also make gardening simpler by reducing problems with weeds and many other pests.

Gardening in containers requires more attention to detail than any other gardening method. The plants have only a small amount of soil for root growth, meaning that water and nutrients are limited. Also, the plants are subject to heat and other stresses. As a result, care requirements are more stringent than in a traditional garden. In addition to the general vegetable gardening techniques discussed later in this chapter, the following considerations apply specifically to container gardens.

Table 2. Growing vegetables in containers.

Vegetable	Light require -ments[a]	Minimum container size	Spacing between plants in containers[b] (inches)	Days from planting to harvest
Beans	FS	2 gallon	2 to 3	45 to 60
Beets	FS/PS	½ gallon	2 to 3	50 to 60
Cabbage	FS/PS	5 gallon	1 plant	65 to 120
Carrots	FS/PS	1 gallon	2 to 3	65 to 80
Cucumbers	FS	5 gallon	1 plant	70 to 80
Eggplants	FS	5 gallon	1 plant	75 to 100
Kale	FS/PS	5 gallon	10 to 15	55 to 65
Lettuce	PS	½ gallon	4 to 6	30 to 35
Mustard greens	PS	½ gallon	4 to 5	35 to 40
Onions	FS/PS	½ gallon	2 to 3	70 to 100
Peppers	FS	2 gallon	8 to 12	110 to 120
Spinach	PS	1 gallon	4 to 6	30 to 40
Squash	FS	5 gallon	1 plant	50 to 60
Swiss chard	FS/PS	½ gallon	4 to 6	30 to 40
Tomatoes	FS	5 gallon	1 plant	55 to 100
Turnips	FS/PS	3 gallon	2 to 3	30 to 60

[a] FS = full sun (10 or more hours of direct sun each day), PS = part shade (6 or more hours of direct sun each day).

[b] Any vegetable that produces large plants should have only one plant per container.

Choosing containers. Containers can be made of clay, wood, plastic, or metal. They can be purchased or homemade. It's best to use new containers to ensure that they are free from contamination (e.g., herbicide residue). The most important considerations are size, mobility, and drainage.

Selecting the proper container size is a balance between supplying adequate soil volume and making sure containers can be moved in case of inclement weather or for winter storage. Table 2 provides recommendations for minimum pot sizes for several common vegetable crops, as well as other information needed to make good container production decisions. Container depth is important because most plants need at least 6 to 8 inches of soil for proper rooting.

Wooden barrels make excellent vegetable pots. Wooden planting boxes also work well and can be purchased or constructed to preferred dimensions. Choose redwood or cedar, which resist breakdown and rot. Wood for container construction should not be treated with creosote (used to preserve railroad ties) or pentachlorophenol (penta) wood preservatives. These preservatives may be toxic to plants and harmful to people. Other options for homemade containers include vertical planters made out of wood lattice lined with black plastic or welded wire shaped into cylinders.

Regardless of whether you purchase or construct a container, be sure there are holes in the bottom of adequate size and number to allow drainage of excess water.

Choosing soil media. Native garden soil by itself does not make good potting soil because it does not provide adequate drainage or air exchange. The best soil media, ironically, are called "soilless mixes." These mixes usually are porous combinations of peat moss, perlite, and sand. Some contain wood chips or bark. Packaged potting soil (available at local garden centers) is relatively lightweight and makes a good container medium. It's much cheaper to make your own soilless mix, but a lot more work.

Soilless mixes are sterile and contain few nutrients. Manufacturers usually add major plant nutrients to mixes, but may not add trace elements that are necessary for good plant growth. This problem can be solved by using the soilless mix as a base and adding compost or a small amount of native garden soil (about 25 percent by volume).

Placing the containers. Providing adequate sunlight for the plants is the most important consideration when placing a container. Ideally, the container should be positioned where plants receive sun all day. However, in limited space situations, this is not always possible. Consequently, the amount of sunlight your container garden receives may determine which crops can be grown. Leaf crops generally can tolerate some shade, while vegetables grown for their roots or fruits need a minimum of 8 to 10 hours of direct sunlight each day. Available light can be concentrated somewhat by providing reflective materials around the plants (e.g., aluminum foil, white-painted surfaces, marble chips on the soil surface). Containers should also be placed to avoid frequent strong winds.

Choosing vegetable crops and varieties for containers. Almost any vegetable crop can be grown successfully in a container. However, the best container crops are those that allow you to make the best use of available space. Examples include many types of herbs, carrots, radishes, lettuce, and crops that bear fruits over a period of time, such as tomatoes, peppers, and cucumbers. Dwarf or miniature varieties of many crops are available, making them suitable for containers even if the standard varieties are too large. With increasing interest in container gardening, plant breeders and seed companies are working to develop vegetables specifically for container culture. These varieties may or may not be miniature or dwarf, but they do grow well in pots and produce as well as standard varieties if properly maintained.

Establishing plants in containers. Because containers can be moved indoors during frost or inclement weather, you can plant vegetables 2 to 3 weeks earlier than in the outdoor garden. Be careful not to plant too early, however, because plants that spend too much time indoors will not adapt well to outdoor conditions once the weather moderates. On the other hand, if a container is too large to move or is designated to remain permanently outdoors, plant the crops at the same time as you would in a traditional garden.

Make sure the potting soil is adequately moist. Plant the seeds as you would in the garden. Use the spacing recommendations listed in table 2. It is a good idea to overplant and thin after emergence to the recommended spacing. If cages, stakes, or other supports are needed, install them just after planting or thinning to avoid root damage later.

Table 2 also provides information on the expected amount of time to first harvest. Your actual growing period may vary, depending on weather conditions and pot location.

Irrigating container gardens. Improper irrigation is the most frequent cause of failure in container gardens. Limited soil volume and extreme exposure results in a high demand for water. Inadequate or erratic irrigation will quickly reduce plant health and productivity.

However, overwatering is just as serious and may be the more common problem. Overwatered plants do not show immediate detrimental effects, but will eventually decline and die due to a reduction in root health. Overwatering is often caused by the presence of a water saucer or catch-pan under the pot. If the catch-pan is constantly full, water will wick back into the pot through the drainage holes and keep the soil too wet. Water only when the plants and soil indicate a need. The soil should never be soggy or have water standing on the surface.

Knowing when to water container plants is a little tricky, but there are a few techniques that may help. Check containers at least once a day (twice on hot or windy days). Use your fingers to feel the soil. It may be dry on top, but should be damp (not sopping wet) below a depth of about 1 inch. If the soil feels dry to a depth below the length of your finger, apply water until it runs out of the drainage holes in the bottom. Another trick is to watch the plants for the earliest signs of water stress—a change in color to dark green followed by mild wilt symptoms. Don't allow wilting to become severe.

In the hottest part of the summer, you may need to water daily or twice a day, depending on the size of the pot. In cool spring weather or on cloudy days, plants may need water only once every 3 or 4 days. If you must be away from the garden for long periods of time, consider installing an automatic drip irrigation system.

Clay pots and other porous containers allow evaporation through the sides of the pots. Plants grown in these types of containers require irrigation more often than those grown in impermeable containers.

To conserve water in containers, try the following techniques:

- Group containers so they shade one another and reduce evaporation.
- Place something impermeable, such as a plastic or rubber mat, under pots to prevent moisture from moving out of the pots and into cement or masonry surfaces.
- Use mulches and windbreaks.

Fertilizing containers. If you purchase a soil mix that includes fertilizer, your plants should have enough nutrients to last 8 to 10 weeks. If plants grow for a longer period of time, you will need to add water-soluble fertilizer, dry fertilizer (slow-release), well-aged manure, or compost at the rate recommended on the product label. Repeat every 2 to 3 weeks. An occasional dose of fish emulsion or compost will add trace elements to the soil.

Do not add more than the recommended rate of any fertilizer, because excess fertilizer may damage or kill the plants. Container soils do not have the buffering capacity provided by large volumes of soil and humus to protect them from over-fertilization. Just because a little fertilizer is good for your plants does not mean that a lot will be better.

Pest control. Vegetables grown in containers can be attacked by the same insects and diseases that are common to any vegetable garden. They are more prone to damage from some pests, such as spider mites. Inspect plants periodically for foliage- and fruit-feeding insects as well as disease symptoms. Treat as needed. For insects, control may be as easy as spraying the plants with a hard stream of water. See the section on pest control later in this chapter for more information.

Other intensive gardening techniques

Interplanting. Growing two or more types of vegetables within the same space at the same time is known as interplanting (figure 8). Interplanting has been practiced for thousands of years in Europe and Japan, but is just now gaining widespread support in this country.

Interplanting can be accomplished by alternating rows within a bed (for example, a row of peppers next to a row of onion), by mixing plants within a row, or by distributing various species throughout a bed. For the beginner, alternating rows may be the easiest system to manage.

To successfully plan an interplanted garden, consider these factors for each plant:

- Length of the plant's growth period and its growth pattern (tall or short, below or above ground)

- Possible negative effects on other plants (e.g., sunflowers and Jerusalem artichokes produce chemicals that can inhibit the growth of nearby plants)
- Season of growth
- Light, nutrient, and moisture requirements

One of the best interplanting strategies is to combine an early crop, such as peas, radishes, or spinach, with a late crop, such as carrots, cucumbers, or squash. The early crop will be harvested by the time the late crop needs the space. Another technique is to plant smaller plants around larger plants (e.g., radishes at the base of beans or broccoli). Shade-tolerant species, such as lettuce, spinach, and celery, can be planted in the shadow of taller crops such as corn. Plants that require large amounts of nutrients, such as cabbage-family crops, can be interplanted with less gluttonous plants such as beans or beets.

Succession or relay planting. Succession planting involves growing multiple crops of the same or different plants in the same space by replanting as soon as harvest is complete. You may laugh at this idea if you live in one of Idaho's short-season climates, which limit the potential of this technique. However, some rapidly maturing crops are amenable to succession planting. Spinach, lettuce, kale, radishes, beets, and peas are good candidates. A fall crop of broccoli or cauliflower may also be possible with the proper succession of crops.



Figure 8. Interplanting—planting different crops together in the same space—is a good way to maximize production in limited space.

Relay planting is an effective option in cold-climate areas. This technique involves planting crops over a several-week period to allow for continuous harvest (figure 9). This method does not improve efficiency of land use, but does keep fresh vegetables available for a longer period of time. This method is especially effective for most salad crops and sweet corn.

Edible landscaping. Although not a new idea, edible landscaping has recently come into its own as an effective vegetable and fruit production technique. It consists of utilizing vegetable and fruit crops as landscape elements. For the vegetable gardener, it usually consists of planting edible crops among permanent elements of the landscape. Vegetables replace or are intermixed with flowers and other ornamental plants in annual and perennial beds.

Edible landscaping has much in common with the interplanting technique described above. You must consider compatibility among vegetables and other landscape plants. Because they are integrated into the landscape, the vegetable plants must not only be productive and healthy, but also must look good and contribute to the overall appearance of the property. They should enhance rather than detract from the landscape.

Vegetable crops are not all equal as edible landscape specimens. Appropriate edible landscape vegetables are those that can be planted in limited numbers, remain green for most of the summer, and provide unique and attractive visual appeal. Some of the best crops for use in edible landscapes include beets, cabbage, cauliflower, carrots, chard, collards, cucumbers, lettuce, onions, parsley, peppers, spinach, and tomatoes.



Figure 9. Relay planting can be used to extend the harvest season of many crops, such as corn. Plants on the right were planted first; those on the left planted later.

Maintenance of an edible landscape is similar to that for other intensive production systems. The processes of soil management, fertilization, irrigation, weed control, and pest management are similar to those described throughout this chapter. The unique part of edible landscaping is that the needs of the vegetable crops must be balanced with the needs of the permanent landscape elements. Because no two edible landscapes have the same plants and situation, it is difficult to provide detailed instructions for installation and care. Experience will provide the best recipe for success.

BUYING, SAVING, AND STORING SEED

Buying seed

Choose seed from a reputable seed company. Make sure the seed was grown and packaged the previous year, rather than stored by the seed company. The seed packet should show a package date.

After buying seed, keep a record of the seed company, variety names, plant performance, production problems (including diseases), and your personal feelings about the quality and flavor of the produce. This record will prove invaluable when selecting varieties in the future. Don't try to rely on memory to recall your favorite varieties; even the best minds create memories that may last a shorter time than the gardening season!

Saving your own seed

Saving your own seed can create a sense of self sufficiency and save money. However, the true benefit is the ability to maintain a vegetable variety that is not available commercially. "Heirloom" or "heritage" varieties are fun to grow and can have a unique appearance and/or quality, but the seed is often hard to obtain. You can keep a steady supply of seed available by saving your own. Participation in a seed-saver's exchange can also be rewarding. You can trade extra seeds for unusual varieties not available through other sources.

Keep the following factors in mind when saving seed:

- Hybrid varieties (usually designated as "hybrid" or "F_1 hybrid" as part of the variety name) produce seed that does not breed true. In other words, if you plant seed harvested from these plants, the resulting offspring will vary in appearance, productivity, and quality. Use only open-pollinated varieties (those that are not hybrids) for home seed production. Some seed dealers have responded to the increasing interest in seed saving by clearly marking open-pollinated varieties in their catalogs.
- Seed can carry diseases into the next year's crop. This concern is minimal in most Idaho climates, but be safe by taking seed only from very healthy plants.
- Completely clean and dry the seed before storing it. A good method is to place the seed on a dry paper towel in a sunny window. Store the dried seed in a cool place (not more than room temperature) where it will remain completely dry.
- Some crops are self pollinated (they produce seed using their own pollen), while others are cross pollinated (pollen is transferred from other plants). Self-pollinated crops include peas, beans, tomatoes, peppers, and eggplants. These are the simplest crops from which to save your own seed.

  Cross-pollinated crops include cucumbers, melons, squash, pumpkins, broccoli, lettuce, radishes, and sweet corn. If you want to save seed from cross-pollinated crops, you must isolate the plants or transfer pollen by hand. If you have ever saved squash seed and found the next crop to be full of unusual types, you know what can happen. You can isolate plants by growing only one variety of that crop, but only as long as there are no other varieties growing in gardens nearby (usually within about a quarter mile). The best way to ensure isolation is to cover the flowers with a paper bag before they open. Some plants have separate male and female flowers, and both must be covered. When the flowers open, use a small artist's brush to transfer the pollen. Then cover the flowers again until they fade.
- For corn, save seed only from open-pollinated heirloom types.
- Some crops, such as beets, carrots, and onions, produce seed in their second year of growth. It is difficult to save seed from these crops, but you can do so by storing roots or bulbs over the winter in the refrigerator and replanting them in the spring.

Many books and web sites provide more detailed information about saving vegetable seed. For example, see the outstanding web site maintained by the International Seed Saving Institute (http://www.seedsave.org/issi/issi.html).

Table 3. Number of years vegetable seeds will remain viable under proper storage conditions.

Vegetable	Average years seeds can be saved
Bean	3
Beet	4
Broccoli	3
Brussels sprouts	4
Cabbage	4
Carrot	3
Cauliflower	4
Celery	3
Chinese cabbage	4
Collard	4
Corn	2
Cucumber	5
Eggplant	4
Endive	5
Kale	4
Kohlrabi	3
Leek	2
Lettuce	1
Muskmelon	5
Mustard	4
Onion	1
Parsley	1
Parsnip	1
Pea	3
Pepper	2
Pumpkin	4
Radish	4
Rutabaga	4
Spinach	3
Squash	4
Tomato	4
Turnip	4
Watermelon	4

Storing seed

Under proper conditions, seeds of some vegetable crops can be stored for several years. Table 3 lists common vegetables and the number of years that seed can be held. However, it can be difficult to provide proper storage conditions. If seeds are not stored properly, the length of time they can be held drops dramatically. To ensure plant vigor, the safest practice is to purchase or produce new seed every year.

Vegetable seed can be stored in the refrigerator or freezer inside a sealed container. It should at least be stored in a cool (below room temperature), dry place. A cool basement storage room can be ideal.

PREPARING THE SOIL

Proper soil preparation is the basis for good seed germination and growth of garden crops. The ideal vegetable garden soil is deep, friable (easy to cultivate), well-drained, and has a high organic matter content. You may ask if such a soil exists! Only a few regions in Idaho have soils that naturally supply these conditions. Appropriate use of soil amendments can improve garden soil and provide the best possible conditions for your crops. Effective soil improvement begins with understanding the current status of your soil.

Testing the soil

Soil testing is the process of sampling soil and completing a laboratory evaluation to determine nutrient availability and chemical characteristics important for plant growth. At a minimum, have your soil tested for basic nutrient content and pH. Soil tests are especially critical in a new garden plot, but soil should be analyzed at least once every 3 years because conditions change over time. Soil tests are done for a nominal fee by the University of Idaho or by private laboratories. Contact your extension office for instructions and sample bags.

One piece of information that comes from a soil test is pH. Soil pH is a measure of acidity or alkalinity. Vegetables differ to some extent in their response to soil pH, but most do well within a pH range of 6.2 (slightly acid) to 7.5 (slightly alkaline). If soil pH is too high or too low, poor crop growth may result, largely because of the effects of pH on the availability of nutrients.

Unfortunately, in most cases we are stuck with the soil we have regardless of whether pH is favorable. It is possible to raise the pH of low-pH soils (common in northern Idaho and some high mountain valleys) by liming. It is nearly impossible, however, to lower the pH of the alkaline soils common to much of southern Idaho. However, you can partially compensate for the lack of nutrient availability in these soils by adjusting fertility practices. One of the best ways to improve nutrient availability is to increase the amount of organic matter in the soil.

Adding organic matter

Organic matter is derived from decomposing plants. It is important because it improves tilth, increases water-holding capacity, improves fertility, and reduces problems with soil diseases. There is no replacement for organic matter in improving soil health and providing good growing conditions for vegetables.

Most Idaho soils are low in organic matter. It can be added in the form of plant waste (such as leaves or lawn clippings), composts, green manures, or aged animal manures. You'll need to add organic matter consistently (every year or two) because it breaks down rapidly in the soil.

Compost is one of the simplest, safest, and most effective organic amendments. You can purchase compost or make it from landscape or household plant-based waste. See the chapter titled "Backyard Composting" to learn the basics of this process. Apply compost by spreading a layer 3 to 6 inches deep on the soil surface. If possible, till it in to a depth of 10 to 12 inches.

Green manure is living plant material that is added to the soil. Effective green manure crops include oats, corn, vetch, clover, and mustard. Grow the green manure crop on the area you want to amend. Mow the crop while it is still green and till in the residue.

In short-season areas, planting a green manure crop may exclude planting a garden in that spot during the amending season. Regardless, this is still a very good practice in a new garden plot. A less disruptive method is to schedule green manure crops into the garden rotation system; reserve a different portion of the garden for a green manure crop each season.

Animal manures should be aged for a year or two or properly composted before application. Manures can be fairly high in salts and may be harmful in excessive amounts. Add 2 to 4 inches of manure and till it in to a depth of 10 to 12 inches. It's best to apply manure in the fall so it has time to completely decompose and salts can partially leach out of the root zone before spring planting.

Fertilizing

Decisions related to fertilizing vegetable gardens can be complex. The type and amount of fertilizer needed depends on factors such as the natural fertility of the soil, soil texture, and amount of organic matter present. Thus, it is impossible to provide universal fertilizer recommendations that apply to every gardening situation.

Fertilizer requirements for individual vegetable crops vary widely, further complicating fertilizer rate decisions. Some crops, such as peas, beans, and beets, need very little fertilizer. Most long-season crops, such as corn, potatoes, and melons, require fairly large amounts. Fertilizer application decisions for a vegetable garden should take into account these crop differences.

Nothing can replace a soil test for providing the information required to make good fertilizer application decisions. If soil test results are not available, you must base fertilizer decisions on reasonable assumptions about existing conditions. Three such assumptions are possible for most Idaho soils:

- Nitrogen (N) is the nutrient most likely to be in short supply. Base fertilizer application rates on the nitrogen requirement.
- Consistent applications of phosphorus (P) and potassium (K) are usually needed. Use a "complete" fertilizer—one that contains all three major nutrients (N, P, and K). The fertilizer should contain at least as much phosphorus and potassium as nitrogen. This assumption is not always true, however; hence, the value of an occasional soil test.
- Your garden soil is probably reasonably fertile to begin with and would grow a reasonable crop of vegetables even if you added no fertilizer. This last assumption can be validated only through experience.

If you feel these assumptions are reasonably valid for your garden soil, the following three-step process should work as a starting point for fertilizer applications. These recommendations are appropriate for a typical Idaho clay loam, silt loam, or sandy loam soil with average nutrient content and a low amount of organic matter.

1. Purchase a fertilizer that contains a moderate amount of nitrogen, high levels of phosphorus, moderate to high levels of potassium, and possibly some sulfur. Fertilizer labels list the content of these nutrients in the order N-P-K. Examples of appropriate fertilizer grades for vegetables are 4-10-6, 5-10-5, 5-10-10, 6-10-10, 10-20-10, 10-45-10, and 15-30-15. It's not necessary to use a product that matches one of these grades exactly, but do seek a product with a similar ratio of major nutrients.
2. Before planting, add fertilizer at the rate of 2 to 3 pounds of actual nitrogen per 1,000 square feet of garden area. (See the chapter title "Soils and Fertilizers" in this handbook for information on how to determine the nutrient content in fertilizers.) This will supply the full seasonal needs for crops that are considered to be light feeders (beans, beets, carrots, chard, lettuce, parsnips, peas, early-harvested potatoes, radishes, rutabagas, spinach, tomatoes grown in a short-season area, and turnips).
3. After the crops are up and growing, sidedress the heavy feeders (broccoli, cabbage, cauliflower, celery, collards, corn, cucumbers, eggplants, kohlrabi, leeks, melons, onions, peppers, late-harvested potatoes, pumpkins, squash, and tomatoes grown in a long-season area) with an additional 2 to 3 pounds of nitrogen per 1,000 square feet. Apply this fertilizer just as the plants start their major growth phase—typically 3 to 6 weeks after planting or transplanting, depending on the crop. Apply the fertilizer near the base of the plants. For this application, you might use ammonium sulfate (20-0-0), which does not contain phosphorus or potassium.

If you use a lot of compost or manure, you can use less fertilizer. For example, if you apply 4 to 6 inches of manure or compost each year, you can reduce the amount of fertilizer applied by one-half to two-thirds.

The principles described above apply to both organic and chemical fertilizers. However, the fertilizer products used are different. Organic fertilizer products include bone meal, blood meal, feather meal, etc. Organic gardeners often rely more heavily on consistent applications of composts, manures, and green manures to supply plant nutrients.

Sandy garden soils require some modification in fertilizer application practices. If your soil is sandy, apply less of the total fertilizer before planting. Instead, make frequent, small applications throughout the growing season. This will provide the plants with the nutrients they need, while reducing leaching losses. A soil test will help you determine your soil texture.

The "Soils and Fertilizers" chapter in this handbook explains more about soils, soil fertility, fertilizer grades, and application methods.

Tillage

The final step in soil preparation is tillage. Ideally, soil should be tilled to a depth of at least 10 inches. This can be very difficult with small garden equipment, however. If you can't till deeply, it may be beneficial to occasionally fracture the soil to a greater depth. Push a long-tine garden fork deep into the ground and pull the handle backward to break up the hard lower layers.

It is important to avoid working soil when it is very wet. Tilling wet soil breaks down the soil structure, causing it to become cloddy and hard. The negative impact of tilling wet soil may last for years. You can tell if your soil is dry enough to work by taking a handful and squeezing it tightly into a ball. If the ball breaks into granular pieces when pressed lightly between your fingers, the soil is ready to work. If the ball remains intact and feels sticky when you squeeze it, wait a few days before tilling.

PLANTING

Planting vegetable seeds outdoors

No amount of care can rescue plants that get off to a bad start due to incorrect planting. In order to germinate properly, seed must be planted at the right depth and must remain moist.

As a general rule, vegetable seeds should be planted to a depth about three times their width (not their length). However, there are exceptions. Some

seeds require light for germination and should be covered with no more than ¼ inch of soil. Most seed envelopes contain planting instructions.

You can cover shallow-planted seed with clear plastic film (such as plastic food wrap) or wet burlap to raise the soil temperature and hold moisture. Remove the covering immediately after the seedlings emerge to prevent burning or abnormal growth of the new plants.

Optimal planting times vary from crop to crop. There is no "one time fits all" for vegetables. Some plants grow well in cool spring weather. Plant these crops well before the last frost. Other vegetables can be severely damaged by cold weather or light frost.

The first step in deciding when to plant is to determine the average date of the last frost in your area. This information can be found in many publications, web sites (for example, http://www.humeseeds.com/frost1.htm), or from your local extension office.

Next, schedule planting based on the frost hardiness of each crop (see figure 10). Some general guidelines are:

- **Three to 4 weeks before the average last spring frost**: Plant cold-hardy crops, including onions, peas, kale, cabbage, broccoli, and cauliflower. (The last three can be transplanted within the same time frame.)
- **A week to 2 weeks before the average last frost**: Plant moderately hardy crops, such as beets, carrots, spinach, Swiss chard, leeks, and lettuce. You can also plant sweet corn at this time if you are willing to take a chance on minor frost damage in order to get an earlier crop.
- **Within a week or 2 after the average last spring frost**: If the weather forecast does not call for cold weather, plant warm-season crops, including beans, cucumbers, eggplants, melons, squash, pumpkins, peppers, and tomatoes. If transplanting these crops, you may need to wait a few more days, depending on the weather forecast.

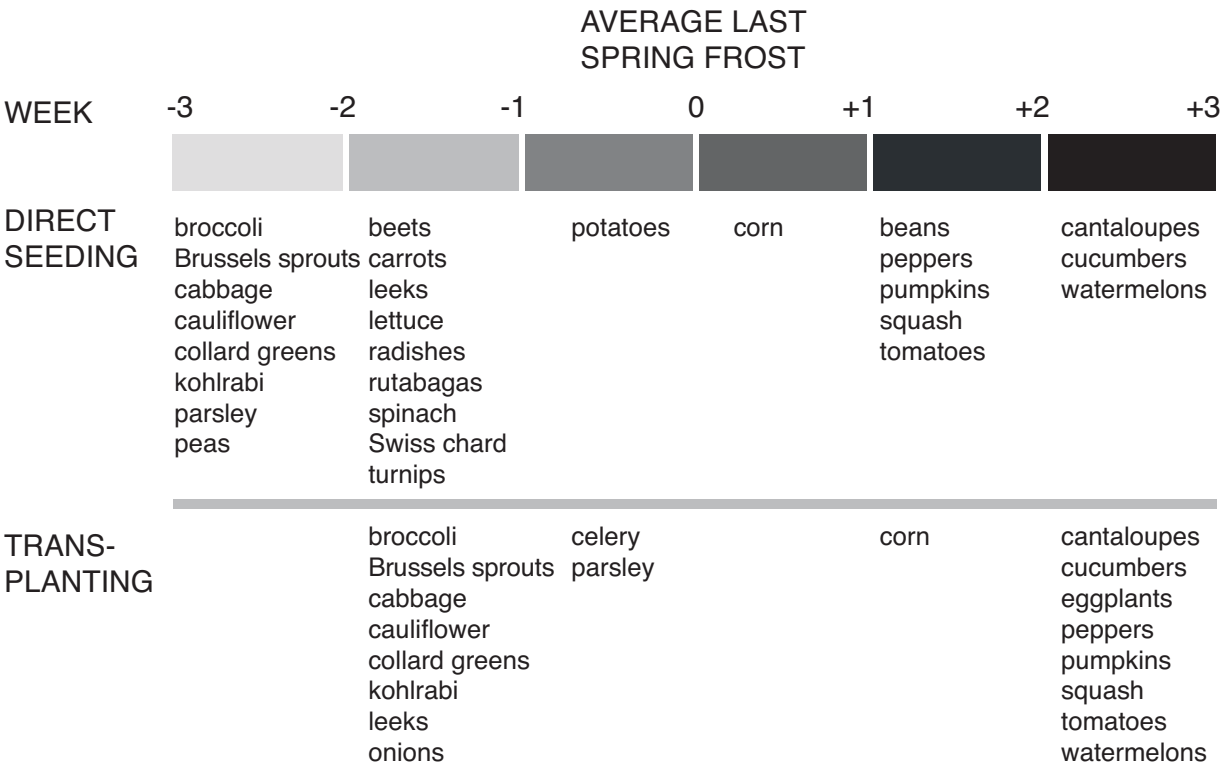


Figure 10. Planting and transplanting guide for vegetable crops based on the date of the last spring frost. On the bar, zero (0) is the date of the last spring frost, as determined for your locale. Each number to the right or left is the number of weeks before (-) or after (+) the average last frost. Crops listed under each number are those that typically can be successfully planted or transplanted during that time.

Bouts of cold temperatures and frost are not the only things that cause problems with emergence and early growth. Soil temperature also affects germination. In the spring, soil is often cold, and seeds of some plants will rot before they have a chance to sprout. Even if the calendar indicates it's time to plant, it is wise to make sure the soil temperature is high enough to allow germination. For cold-hardy crops, the minimum daytime high soil temperature for planting is 50°F. Moderately hardy crops need soil temperatures of at least 55°F, and warm-season crops need 65°F. Table 4 outlines the minimum and optimal soil temperatures and expected time to emergence for common vegetable crops.

Table 4. Vegetable germination and emergence as related to soil temperature.

Crop	Days to emergence from seeding[a]	Optimal soil temperature for germination (°F)	Minimum soil temperature for planting (°F)
Beans	5 to 10	70° to 80°	65°
Beets	7 to 10	50° to 85°	50°
Broccoli	5 to 10	65° to 75°	50°
Cabbage	5 to 10	65° to 75°	50°
Carrots	12 to 14	70° to 80°	55°
Cauliflower	5 to 10	65° to 80°	55°
Celery	10 to 18	65° to 75°	55°
Collards	5 to 10	65° to 75°	50°
Corn, sweet	7 to 10	70° to 85°	65°
Cucumbers	7 to 10	70° to 85°	65°
Eggplants	8 to 12	70° to 85°	65°
Endive	10 to 14	65° to 75°	55°
Kohlrabi	5 to 10	65° to 75°	50°
Leeks	10 to 14	65° to 70°	50°
Lettuce	7 to 10	65° to 70°	55°
Melons	5 to 10	80° to 85°	65°
Onions	10 to 14	65° to 70°	50°
Parsley	10 to 25	65° to 70°	55°
Parsnips	14 to 21	65° to 70°	55°
Peas	7 to 14	65° to 70°	50°
Peppers	10 to 14	75° to 85°	65°
Potatoes	10 to 18	65° to 70°	55°
Pumpkins	7 to 10	65° to 75°	65°
Radishes	5 to 7	65° to 70°	50°
Rutabagas	7 to 15	65° to 70°	50°
Spinach	7 to 14	65° to 70°	55°
Squash	7 to 14	70° to 85°	65°
Swiss chard	7 to 14	65° to 75°	55°
Tomatoes	7 to 14	75° to 80°	65°
Turnips	7 to 14	65° to 70°	50°

[a] Emergence may take several days longer if soil temperatures are consistently below the optimum, as often occurs during spring in much of Idaho.

Once planted, you *must* keep the soil moist until the plants begin to emerge. In some years, spring rain and cool weather make irrigation unnecessary. However, in most years, frequent light watering is required to get seed off to a good start. You may need to water deeply seeded crops every 2 or 3 days and shallow-seeded crops as often as two times a day.

Producing and establishing transplants

Many vegetable crops do better when transplanted rather than direct seeded in the garden. Transplanting makes weed control simpler, enhances the growth and quality of crops that prefer cool, spring weather (such as broccoli and cauliflower), shortens the time to harvest of many fruit-bearing crops (such as peppers and tomatoes), and allows us to grow many crops that are marginally adapted to short-season climates (such as melons).

Some vegetables are very difficult to transplant. (The length of this list varies, depending on the gardener's skill level.) Other vegetables fall into a middle category; they can be transplanted successfully, but only if proper precautions are followed. The last group includes vegetables that can be transplanted with minimal frustration. See table 5 for a list of vegetables that can be successfully transplanted.

You can purchase transplants or grow them yourself from seed. It's easier to purchase plants, and greenhouse-produced transplants are often healthier than those produced at home because they are grown under ideal conditions. However, growing your own transplants does have advantages. You can produce unusual varieties, save money, and ensure that your transplants are at the proper growth stage when you are ready to plant.

Growing transplants without good greenhouse facilities can be a challenge. The most important factors are light, soil mix, irrigation, proper size and growth stage, and hardening.

Starting transplants

It can be tricky to know when to plant seeds for transplants. The objective is to have the seedlings at the optimal stage of growth when it's time to transplant—assuming the unpredictable Idaho weather will be suitable for planting on the day you expect to transplant. It takes planning to ensure that transplants are neither too big nor too small when you are ready to move them to the garden.

You need two pieces of information in order to develop a planting schedule for vegetable transplants: (1) the date the transplants will be planted in the garden, and (2) the amount of time needed to produce appropriate-sized transplants. You can calculate the transplanting date if you know the last average frost date for you locale. Use the following guidelines (also see figure 10):

- **Cole crops (cabbage, broccoli, cauliflower, kale, brussels sprouts, etc.) and onions**: Transplant 2 to 3 weeks before the average last frost.
- **Most salad crops (lettuce, Swiss chard, spinach, etc.)**: Transplant a week or so before the average last frost.
- **Tender crops (tomatoes, peppers, eggplants, squash, melons, etc.)**: Transplant about 1 or 2 weeks after the average last frost if the weather forecast is for reasonably warm and stable conditions.

If you protect your transplants with hot caps, row covers, etc., you sometimes can move the transplant date forward by a week or two.

Once you know the anticipated date of transplanting, see table 6 to find the number of weeks needed to produce transplants of your chosen crops. Then count backward from the transplanting date to find the date you should plant seeds.

It is best to use a soilless planting mix containing peat to start seedlings. Soilless mixes are usually free of disease organisms that can cause

Table 5. Ease of transplanting vegetables.

Appropriate for transplanting and easy to handle	Appropriate for transplanting but require extra care for success	Inappropriate for transplanting or do not easily survive the process
Broccoli	Celery	Beans
Brussels sprouts	Cantaloupes[a]	Beets[b]
Cabbage	Corn	Carrots[b]
Cauliflower	Cucumbers[a]	Peas
Chinese cabbage	Pumpkins[a]	Radishes[b]
Collards	Squash[a]	Rutabagas[b]
Eggplants	Swiss chard	Spinach
Leeks	Watermelons[a]	Turnips[b]
Lettuce		
Onions		
Parsley		
Peppers		
Tomatoes		

[a] Transplant vine crops (cucumbers, melons, squash, and pumpkins) when seedlings are very young (one or two true leaves) and very vigorous. Cover transplants and protect them from wind and sunburn for about 2 weeks after transplanting.

[b] Root crops (beets, carrots, radishes, rutabagas, and turnips) are often easy to transplant, but the roots will branch or have other quality problems as a result of root disturbance.

Table 6. Number of weeks required to produce transplants from seed.

Crop	Weeks to produce transplants from seed[a]
Broccoli	5 to 7
Brussels sprouts	5 to 7
Cabbage	5 to 7
Cantaloupes	3 to 4
Cauliflower	5 to 7
Celery	8 to 10
Collards	5 to 7
Corn, sweet	3 to 4
Cucumbers	3 to 4
Eggplants	6 to 8
Endive	4 to 8
Kohlrabi	5 to 7
Leeks	4 to 6
Lettuce	3 to 5
Onions	6 to 8
Parsley	6 to 8
Peppers	6 to 8
Pumpkins	3 to 4
Squash	3 to 4
Tomatoes	5 to 9

[a] The number of weeks needed to produce transplants is based on growth at room temperature.

damping-off, a fungal disease that causes young seedlings to fall over and die. They also hold a large amount of water and maintain the integrity of the root ball when it is time to transplant. You can purchase premixed potting soil or mix your own. A mix of 50 percent vermiculite or perlite and 50 percent fine sphagnum peat (plus a little fertilizer) is excellent for starting seeds.

To save space, you can plant the seeds in flats and then transplant the small seedlings into small pots or other individual containers to complete growth in preparation for transplanting outside. An alternative is to plant the seed directly into individual containers such as small pots, six-pack trays, peat pellets, or peat pots. With this method, it is best to plant extra seed and thin the plants after emergence to the desired number in each pot (usually two or three).

Planted seeds and seedlings are extremely sensitive to drying out. If the air in your home tends to be dry, it may help to cover the flats or pots with clear plastic in order to maintain uniform moisture. Do not keep the soil soaking wet, however, since excess moisture is conducive to damping-off. You can prevent or reduce damping-off by sprinkling a thin layer of milled sphagnum moss, which contains a natural fungicide, on top of the soil.

Caring for transplants

More home-grown seedlings are lost to inadequate light than to any other factor. Vegetable seedlings grown under low-light conditions are likely to be spindly and weak. They frequently are killed by damping-off. If they survive the early growth phase, plants are often too tender to survive the move to the garden.

For these reasons, transplants should be grown under conditions that include or mimic at least 10 hours of sunlight each day. If you do not have a sunny room or back porch with a southern exposure, you will need supplemental lights. Grow-lights supply a good spectrum of light. Mount the lights just above and nearly touching the plants.

Transplants must be healthy, growing rapidly, and adapted to outside conditions before they go to the garden. Thus, you must maintain optimum moisture and fertility conditions during growth. Never allow plants to dry out or run out of nutrients. Plants should be dark green and not lose any leaves. If growth is retarded, transplants may never recover sufficiently to produce a good crop.

Hardening off

About a week before you plan to move transplants to the garden, you should "harden them off." Hardening off means to slowly adapt the plants to outside conditions. This process reduces transplant shock and the risk of transplant death. Harden off the plants over a 1-week period by moving them outdoors for increasing amounts of time. Start with less than 1 hour the first day, and eventually leave them outside for much of the day. Move them indoors at night (unless a warm night is forecast) and during inclement weather (especially if it is windy). Transplants will use more water outside, so water accordingly.

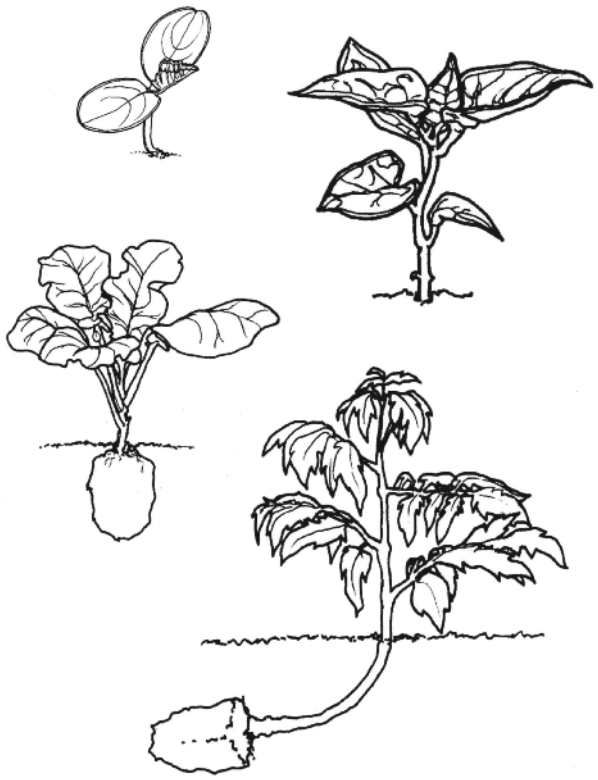


Figure 11. Optimal transplant size of vegetable crops. Transplant vine crops (cucumbers, melons, squash, and pumpkins) when very small. Plant them at the same depth as they are growing in the pot (top, left). Peppers, eggplants, and most other transplanted crops can be transplanted at a moderate size. Plant them slightly deeper than in the pots (top, right). Cole crops (cabbage, broccoli, cauliflower, Brussels sprouts, kohlrabi, and kale) should be relatively small and vigorous. Plant them at the same depth as they are growing in the pots (bottom, left). Tomatoes can be transplanted when quite large. Place tall tomato plants sideways in a trench and cover the stem to the lowest leaves (bottom, right).

Transplanting

Some vegetable transplants have specific requirements (figure 11):

- Cole crops (cabbage, broccoli, cauliflower, brussels sprouts) should not be too large when transplanted. If the stem diameter is larger than about ¼ inch, the plants likely will "button" or "bolt," meaning they will produce very small heads or go to seed after cold weather.
- Vine crops (cucumbers, melons, squash, pumpkins) should be very young when transplanted, having at the most only one or two true leaves. They should be very vigorous. Otherwise, they develop a root hardening problem that makes them very slow to recover from transplant shock. Also, newly transplanted vine crops are very susceptible to windburn and sunburn. Cover them with paper or plastic for about a week after transplanting.
- Tomatoes are relatively easy to transplant. Even very large plants establish with few problems, allowing you to get an early start on production.

Here are a few additional tips for successfully-transplanting vegetables:

- Prepare garden soil before transplanting. Many soil amendments, such as aged manures, sulfur, limestone, rock fertilizers, and green manures, require time to break down. Mix these materials into the soil the fall before planting, or at least several weeks before planting.
- Transplant on an overcast day, in late afternoon, or in early evening to minimize wilting. Water the potted plants thoroughly just before transplanting.
- Handle plants carefully. Avoid disturbing the roots or bruising the stems.
- Dig a hole large enough to hold the plant roots. Plant vegetables only very slightly deeper than they were growing in their pots. Tomatoes are an exception. They will develop roots all along the stems, and you can plant them deeply enough to leave only two or three sets of leaves exposed.
- Press soil lightly around the roots and water well. Pour a cup of liquid starter fertilizer solution around each plant, mixed at about half of the concentration recommended on the label.
- Protect plants from wind and sun for a few days after transplanting. Place newspaper or cardboard on the south side of the plants, or cover them with commercially available devices, milk jugs, baskets, or upside-down flower pots (use clear plastic so the sunlight will pass through).
- Water the plants once or twice a day for about 1 week. Then water two or three times during the next week before going to a normal irrigation routine. Overwatering can cause transplants to suffer from root rots, so don't overdo it.

CARING FOR YOUR GARDEN

Irrigating

Under Idaho conditions, proper irrigation is essential for productive vegetable gardens. Watering maintains growth during the summer. It also can improve seedling emergence, reduce soil crusting, improve germination and plant establishment, and stimulate growth of transplants. Proper irrigation—exactly meeting your plants' water requirements—is the single most important factor in growing a high yield of good quality vegetables. See the "Soils and Fertilizers" chapter in this handbook for a discussion of general principles related to soil water and irrigation.

Garden water demands and irrigation scheduling are the result of complex interactions between climate, weather, soil type, plant species, and irrigation practices. Thus, no single recipe is suitable for all gardens. Taking the time to learn about proper irrigation in your own situation will pay dividends. The following principles can help you make good irrigation decisions for your vegetable garden.

- In most locations in Idaho, nearly all of a vegetable garden's water needs must be met through irrigation. Once they approach full size, most vegetable plants use ¼ inch of water per day or slightly more. Thus, a summer garden will need around 2 inches of water per week. Most soils will not hold this much water. In order to avoid plant stress, plan to irrigate twice each week, with the total of the two irrigations being about 2 inches.
- In the spring, when weather is cool and plants are small, vegetable plants may use less than half this amount of water. In the fall, when plants start to mature, water use will also decline.

- You can measure the amount of water applied by a sprinkler by putting a can under the sprinkler. If the water in the can is ¼ inch deep at the end of the irrigation, you have applied ¼ inch.
- Plants use the same amount of water regardless of soil type. However, sandy soils hold less water, so plants use the available water very quickly and then become stressed. If your soil is sandy, water more frequently but apply less water each time.
- Sprinkler irrigation is a simple method for applying water uniformly. However, sprinklers wet the leaves and encourage disease development. They also splash dirt on leaves, which may add some "grit" to your meals. If these are problems in your garden, consider using a bottom-up irrigation method such as soaker hoses or a drip system.

Controlling weeds

Weeds are a constant source of frustration to vegetable gardeners. Weeds not only reflect negatively on the gardener's expertise (the neighbors are always watching!), but they also use water and nutrients, compete for available light, and reduce the yield and quality of vegetables.

Keeping the garden clean of weeds one year doesn't mean they won't be back the next. The old saying, "One year's weed, 7 years' seed," contains more truth than myth. Although weeds will always be present, however, some control methods will make them easier to live with.

Cultivation

Hand pulling and digging weeds is probably the best choice for small gardens and raised beds. You can make the task more pleasant with the use of knee pads. Hoeing is preferred in larger spaces. Hoeing can damage root systems of large plants, so push the blade of the hoe into the soil just deeply enough to sever weed roots. Stay several inches away from the base of vegetable plants. Manually powered rotary cultivators can supplement the use of a hoe. They do a good job on long rows and pathways if the soil is not too wet or dry and if weeds are not too big.

A power tiller may be the tool of choice for large gardens that are arranged in wide rows. If you plan to use a power tiller for weed control, plant the vegetable rows far enough apart to till between the rows without damaging the plants. Make rows at least 8 inches wider than the tiller blades. Once plants are large enough to touch neighboring plants across the rows, stop power tilling in order to prevent damage to the roots or leaves.

Cultivation is best done when the soil is somewhat moist, but not wet. The best time to cultivate is 2 or 3 days after rain or irrigation. Working wet soil will damage the soil structure, especially in the case of fine-textured soils, making the soil compacted and cloddy. On the other hand, when the soil is dry, weeds are difficult to pull and hoeing is a chore.

After hand-pulling weeds, you can lay them on top of the soil to dry out and then turn them under (if they are not yet flowering). Turning under weeds provides organic matter to the soil. Avoid irrigating for a day or two to prevent the weeds from rooting and "coming back to life."

Some common weeds, such as purslane, nutgrass, quackgrass, and other rhizomatous grasses, will reroot with the first added water and continue to grow. It may be best to remove such difficult weeds from the garden. Also, if weeds are mature enough to produce seed, remove them from the garden to prevent seed dispersal.

Mulching

Mulching can reduce the need for weeding. A thick layer of organic mulch will prevent most annual weed seeds from germinating, and those that do germinate are usually easily pulled. Organic mulches can include straw, grass clippings (make sure they are free of herbicides), bark (small enough to be tilled under at the end of the season), wood chips, or sawdust.

Mulching with black plastic film can also be very effective at reducing weed growth. Using black plastic mulch on the rows and an organic mulch between the rows will nearly eliminate annual weed problems. Mulches are less effective at controlling perennial weeds such as quackgrass and bindweed. Elimination of these difficult weeds will probably require off-season (early-spring or late-fall) applications of herbicides over a period of years.

Close spacing

When spaced close to each other, established vegetable plants shade the soil and prevent the growth of many weed seedlings. Close spacing is easily achieved in a well-planned raised bed, but it also works in victory gardens. Place plants closely

enough together so that the foliage of adjacent plants forms a closed canopy when the plants are mature.

Other practices

One unusual weed control method is to plant grass between rows and keep it mowed throughout the summer (figure 12). This grass is called "living sod" and is a good choice for controlling weeds between raised beds.

The use of a cover crop (such as alfalfa, clover, vetch, or rye) over several seasons or years can reduce weed problems. This method requires leaving the cover crop area uncultivated, which reduces gardening space. Cover crops should be mowed or harvested regularly, which can be time-consuming and difficult without appropriate tools.

A few herbicides labeled for use in home vegetable gardens can be applied over the top of growing vegetable plants. Most can be used safely and are moderately effective, but improper applications can damage crops. Herbicides are more effective when applied as a preventive measure before planting. First remove all existing weeds from the garden. Follow all label instructions.

Controlling pests

In most Idaho vegetable gardens, you can ignore insect pests if you are willing to put up with a little damage and minor losses of edible produce. However, pests occasionally show up in numbers sufficient to be a serious problem.

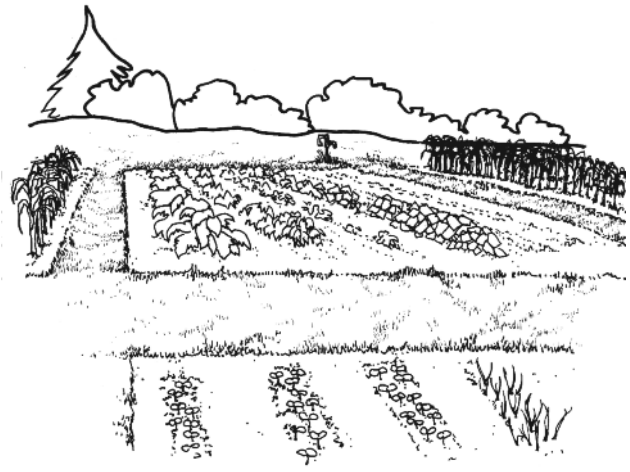


Figure 12. The use of living sod—the practice of planting and mowing grass between vegetable garden plots—is a good way to control weeds. This method is effective around both bordered or open blocks.

The following five simple strategies will help you manage insects, slugs, and snails in a vegetable garden. The insect control chapter of this handbook includes more detailed information.

- Be a sanitary gardener. Insects often overwinter in garden refuse, so clean up dead plant material at the end of the year. If you want to return the organic matter to the soil, till or plow the garden after harvesting the last crops.
- Maintain good plant health. Healthy plants can often partially defend themselves from pests. Even if insects do some damage, the plants will have a good chance of recovering.
- Use physical barriers and cultural controls. You can keep some types of pests at bay by preventing access to your plants. For example, collars around the lower stems of small plants will foil cutworms. Wood ashes or sharp sand will discourage slugs and snails. Other methods include using colored plastic mulches and spraying insects with a hard stream of water.
- Encourage or release beneficial insects. A little patience will go a long way toward controlling many insects, such as aphids. Once pests show up, their predators will arrive and begin eliminating them. Purchasing and releasing beneficial insects such as ladybugs and lacewings may speed up the process. Two things will increase populations of predatory insects. One is to allow a few pest (prey) insects to be present. Predators will not come if there is nothing to eat, so allow a few pests to persist. The other strategy is to avoid using broad-spectrum insecticides. These products may kill pests, but they also eliminate many predators.
- Judiciously use pesticides as a last line of defense. Some insects become serious problems and do not respond to other control methods. For many insects, both organic and synthetic insecticide options are available. If you choose to use insecticides, direct the application to the problem rather than broadcasting an insecticide across the garden. Also, use products that target the specific pest you are trying to control. The goal is to control the pest without harming the beneficial insects that naturally reduce pest populations.

Insects and other pests that commonly infest Idaho gardens at damaging levels include the following.

Aphids

These soft-bodied insects are usually found crowded at the ends of succulent new growth. Insecticidal soaps or a hard stream of water that knocks them off the plant usually are sufficient to eliminate damage. Also, aphids will almost always be eliminated by predators if you are patient enough to let their natural enemies do their work.

Grubs and wireworms

These soil dwellers often damage the roots and lower stems of plants. They are difficult to control and may require the use of a soil-applied insecticide before planting. Thus, you must know the garden's history and realize the problem exists before damage appears. Once damage is visible, it is hard to apply effective controls without damaging young plants.

Cutworms

This pest often kills seedlings and transplants by chewing through the stems at ground level. Cabbage, broccoli, tomatoes, and other soft-stemmed transplants are common victims. Placing cardboard collars around the base of plants is an effective way to prevent damage. Some insecticides are also effective.

Corn earworm

This pest is common in the warmer regions of Idaho. Control usually requires the use of an organic or synthetic insecticide, applied once or twice while the plants are in silk. Begin control measures when the silks appear and continue as long as they are green and pliable.

Slugs and snails

Slugs and snails are less of a problem in our dry climate than they are in wetter areas. In fact, if you have a slug problem, you may be watering too much and too often. Water less, and the problem may be reduced. If reducing irrigation doesn't solve the problem, baits and traps can be partially effective.

Cabbage looper

These slender green caterpillars infest all cole crops (broccoli, cabbage, cauliflower, kale, etc.). They chew holes in the leaves, deposit web-like material, and leave their frass (droppings) on the plants. They can be ignored in small numbers, but may require control with *Bacillus thuringiensis* (the organic pesticide sold as Bt) or another insecticide if they become very numerous.

Tomato hornworms

These large, ferocious-looking caterpillars can be very damaging to tomato and potato plants. One large individual can defoliate a plant in a day or two. Physical control is the best method for eliminating this occasional pest. Pick them off the plants and step on them or squeeze them between two rocks. For the squeamish, simply remove them from the garden.

Colorado potato beetles

These pests are a serious problem on potato plants and occasionally on tomatoes. If only a few are present, you can remove them from plants by hand. If numerous, they may require an insecticide. A hard stream of water may knock them from plants, but unless they are very small, they likely will climb back onto the plant and keep eating.

Mexican bean beetle

The bright-orange, prickly-looking larvae of this beetle can quickly skeletonize leaves of bean plants. Heavy infestations may require an insecticide application.

Controlling plant diseases

The dry climates common to Idaho limit the number of diseases in vegetable gardens. However, a few serious problems should be monitored.

Viruses

A number of common virus diseases occur on vegetable crops. Examples include zucchini yellows, cucumber mosaic, potato leafroll virus, tomato spotted wilt, and tomato mosaic. Viruses are difficult to control. Once a plant is infected, it cannot be cured. The only solution is to remove the affected plants to prevent spread to healthy plants.

If you have recurring problems with any virus disease, you will need to identify the virus and learn about the disease and its vectors. Vectors are organisms, usually insects, that spread a disease. Develop a strategy to control these vectors. You may need to seek help from a Master Gardener, extension educator, nurseryman, or other qualified person.

Bacteria

Many fruit rots and some leaf spot diseases are caused by bacteria. There are no chemical products registered for control of bacteria in vegetable gardens. The best methods for controlling these diseases are cultural. Keep fruit off the ground and make sure

to allow plant surfaces to dry between watering. Eliminate plant refuse from diseased plants.

Fungi

The most common plant diseases involve fungal pathogens. Some fungal diseases live in the soil and attack the plant through the roots; others directly attack leaves, stems, flowers, and fruits.

Crop rotation—moving each vegetable to a different place in the garden each year—is a good way to control soil fungi. Rotation is especially important for controlling verticillium wilt in potatoes, peppers, and tomatoes; club root in broccoli, cauliflower, and other cole crops; and vine wilts in the vine crops (squash, cucumbers, and melons).

Keeping fruit off the ground helps prevent fruit damage. Limit the impact of foliar fungi by allowing foliage to dry between irrigations. However, some fungi, such as powdery mildew, may still become a problem on many crops. Foliar fungal problems that return every year may require fungicidal applications. Most fungicides work best if they are applied before plants show symptoms. Thus, the decision to use fungicides may need to be based on past history.

FURTHER READING AND RESOURCES

Web Sites

Many University of Idaho publications about gardening are available from your county's UI extension office or online at http://info.ag.uidaho.edu.

The University of Idaho maintains a gardening web site that includes information on producing vegetables. It is called "Idaho Landscapes and Gardens" and can be accessed at http://www.extension.uidaho.edu/idahogardens/

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Chapter 21

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Chapter 21
Vegetable Crop Recommendations

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Adapted from a document originally prepared by George F. Gardner
Illustrations courtesy Clipart ETC, Florida Center for Instructional Technology, University of South Florida

INTRODUCTION

Understanding the growth characteristics and management requirements of individual vegetable crops can be important in helping gardeners achieve superior productivity and quality. This chapter provides information about some of the most common vegetables produced in Idaho gardens.

The recommendations provided here are not the final word in growing vegetables. Every gardener has a unique situation created by his or her climate, soils, property, and personal objectives. Nothing replaces experience. This chapter is a good starting place, but each gardener should rely as much on experience as on the written word.

Fertilizer recommendations

Determining the optimal fertilizer rate for each vegetable crop can be challenging. When establishing a vegetable garden, and periodically thereafter, it is a good idea to take a soil sample and have it evaluated by a competent laboratory. If a garden space has been significantly improved, such as by the addition of topsoil, it is also wise to test the soil.

The soil test will provide the basis for fertilizer application rates. Private soil laboratories often supply recommendations along with test results. If recommendations are not provided, Extension educators can help you interpret the soil test results.

In addition to helping you decide how much fertilizer to apply, soil tests can help you choose appropriate fertilizer products. Many fertilizer formulations are available, making it possible to meet plant needs in a variety of situations. For example, if a soil test indicates low levels of nitrogen (N), but high levels of phosphorus (P) and potassium (K), an appropriate product would be high in N but low in the other nutrients, e.g., 21-0-0 (N-P-K) or 46-0-0. On the other hand, if N is high and other nutrients are somewhat low, it might be best to choose a 5-10-10 or 10-10-10 formulation. See the chapter on "Soils and Fertilizers" to learn how to calculate fertilizer application rates.

Once a garden is in successful production, it is not essential to test the soil every year. In this case, you can follow recommendations based on average soil nutrient levels, such as those included in this chapter. If they do not prove suitable to your situation, test your soil and make adjustments accordingly.

Consumptive yield

Information on consumptive yield can help you determine how much of a crop to plant. The information in this chapter will enable you to calculate planting requirements based on your family's preferences. This information is valuable and difficult to find.

Nutrition

Nutrition information can help you create a balanced diet. USDA researchers say that every person should eat 2.5 to 3.5 cups of vegetables every day. Vegetables contain many critical nutrients that are difficult to obtain from other foods. Researchers are learning that the nutritional value of vegetables goes far beyond vitamins and minerals. Vegetables also include many compounds that help reduce the risk of cancer, reduce the impact of aging, strengthen the immune system, and protect memory and eyesight. Any crop that supplies 5 to 20 percent daily value (DV) of a nutrient is considered a "good source"; any crop that supplies more than 20 percent DV of a nutrient is considered an "excellent source."

Soil temperatures

Successful planting involves many things, including placing seeds in an environment in which they can germinate and grow. Soil temperature is critical to successful establishment and early growth of all crops. Some species, such as radishes, carrots, and beets, are categorized as cool-season crops and can germinate in soils as cold as 40°F. Watermelons and tomatoes, on the other hand, need soil temperatures of at least 60°F.

At minimum germination temperatures, most crops may emerge, but emergence will take a long time, and seedlings sometimes have more problems with diseases and pests than those growing in warmer soil. At optimal soil temperatures, seeds emerge most quickly, and plants have the fewest problems getting established. Optimal soil temperatures are often 20 to 30 degrees warmer than minimum temperatures.

In Idaho, if we wait for optimal soil temperatures, it often is too late to grow a garden. Thus, we have to balance the needs of the seeds with the reality of where we live. Somewhere between the minimum and optimal soil temperature is usually good enough to get plants off to a healthy start.

Recommendations for planting-time soil temperatures in this chapter are within this range. You'll need to balance these recommendations against other factors, such as the need to start plants early enough to allow harvest within the normal growing season.

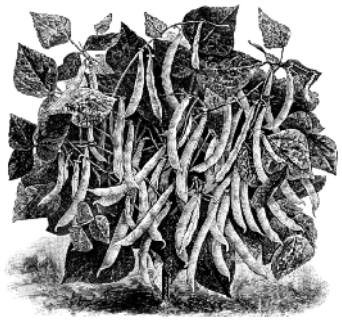
In Idaho, we often see large swings in temperature from day to night. Although soil temperatures do not vary as widely, they do somewhat mimic air temperatures. Thus, soil temperatures can be suitable for planting during the day, but fall lower at night. It is the daytime maximum soil temperature that is most important. If soil temperatures are within an acceptable range during much of the day, germination and emergence will occur normally.

Follow these steps to measure soil temperature.

1. Obtain a good soil thermometer (available at nurseries and garden stores).
2. Locate the exact spot where you will plant the crop of interest. Even a few feet away, the conditions can be different because of shade, structures, etc.
3. Insert the probe to the depth at which you will plant the seed (about 1 inch is a good average for all seeds) so you can test the actual location of the seed.
4. Wait 1 to 2 minutes for the probe to stabilize.
5. Read and record the temperature.

Take the temperature over a period of days. It's best to test at the time of day when maximum (5 to 7 p.m.) and minimum (6 to 8 a.m.) temperatures occur. With this information, you can compute an average daily soil temperature. Many publications use the daily average for making planting recommendations. (In this chapter, recommendations are based on daily maximum temperatures rather than on average temperatures.)

BEANS



Snap beans (*Phaseolus vulgaris*), grown for the immature pod, originated in Central America. Both bush and pole types were widely used by native peoples. Bush beans ripen earlier, but pole bean yields are higher. There are several popular types of snap beans, including wax, flat pod, green, and purple beans. Other types of beans that enjoy some popularity include shell beans, fava beans, lima beans, and soybeans.

Bush beans are the most popular type of snap bean. Because these beans grow to a certain size, blossom, set fruit, and then stop growing, they are referred to as determinate. Bush beans provide the advantage of having all the pods reach harvestable size at nearly the same time. Pole beans, on the other hand, are indeterminate. They continue to grow and produce throughout the season and will have both blossoms and mature beans on the same plant. Pole beans provide fresh pods over a long period of the summer.

Growing suggestions

Achieving an acceptable stand of beans begins with selection of quality seed. Bean seed that is damaged (e.g., cracked seed coats) will not emerge properly, if at all. Inspect seed for damage before purchasing.

Soil type and soil preparation

Beans do best on lighter soils, but will grow on almost any well-drained soil. Do not till wet soils in preparation for planting beans.

Beans produce best in soils with sufficient organic matter. Soils low in organic matter should be amended with compost or manure (added the previous fall, if possible). Work soil well to produce a deep, friable bed. Good soil tilth helps beans develop a healthy root system.

Planting

It is best to plant beans directly into the garden 1 to 3 weeks after the average last killing frost in the spring, when the daytime air and soil temperatures approach 65°F. Planting into cold soils will reduce seedling emergence and vigor.

Some people soak vegetable seeds overnight before planting them to hasten germination. This practice is discouraged for beans, as it often injures the seed, resulting in poor germination and weakened plants.

Planting specifications:

- Seed spacing: 1.5–2 inches
- Final spacing: 3–6 inches
- Ounces of seed per foot: 0.13
- Row width: 18–30 inches
- Seed depth: 1.5–2 inches
- Germination: 6–14 days

Fertilizer

Beans are a legume and can meet most (but not all) of their own N needs through their N-fixing ability. If you plant beans into soils where legumes haven't grown before, it might be helpful to inoculate the seed with rhizobium bacteria to stimulate N fixation. Inoculum can be purchased at garden centers.

Although beans require minimal applications of N, levels of P, K, and other nutrients must be adequate to ensure productivity. Apply fertilizer during soil preparation. A 5-10-10 or similar fertilizer formulation is usually adequate. Add the equivalent of 0.1 to 0.2 lb N (in combination with P and K) per 100 square feet.

Weed control

Season-long weed control is important for beans because they are only moderately competitive with weeds. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Be careful when cultivating close to plants to avoid damaging the roots.

Irrigation

Beans have a shallow root system and little tolerance of drought stress. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1 to 1.5 inches of water every 3 to 5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Several insects can infest beans in Idaho, but they rarely reach population levels that require control. Spider mites can be a problem in some years when the weather is hot and dry. They are best controlled by using overhead irrigation or spraying the leaves with a hard stream of water for several days in a row. Loopers, armyworms, and Mexican bean beetles can damage leaves. In cases of severe infestation, these pests may require the use of a labeled organic or traditional insecticide.

Diseases

Many fungal, bacterial, and viral diseases affect beans. However, if good-quality seed from a reputable supplier is used, diseases rarely become serious in Idaho gardens. Seed and root rots can affect seedling emergence and early plant growth. Prevent these diseases by applying little or no irrigation during germination and early seedling growth. White mold, a fungal disease that rots the pods if they touch the ground, can be a problem if the soil surface remains wet for long periods of time. Allowing the soil to dry slightly between irrigations usually controls this disease.

Harvest

Harvest beans when pods are about 3 inches long and before the seed is much larger than the diameter of a pencil lead. Harvest every 3 or 4 days to prevent over-maturity. Frequent picking of pole beans stimulates the plants to produce new pods and helps to ensure a heavy yield.

Storage

Quality is highest if beans are consumed or processed immediately. However, they can be held for a few days under refrigeration and high humidity without a serious loss of quality. If allowed to wilt, quality diminishes rapidly.

Consumptive yield

Compute household planting requirements as follows:

- 6–12 lb fresh beans per person
- 12–14 lb canned or frozen beans per person
- Each foot of row will yield 0.5 lb.

Plant 12–52 feet of row per person.

Nutritive value

Beans contain zea-xanthin, which is known to improve eye health and reduce the effects of aging. They are a good source of vitamin C, vitamin K, vitamin A, vitamin B6, folate, thiamin, riboflavin, phosphorus, and magnesium. One hundred grams (3.5 oz) of fresh green snap beans without butter or salt contain 31 calories, 1.8 grams of protein, 0.2 gram of fat, 7 grams of carbohydrates, and 2.7 grams of dietary fiber. Fresh snap beans contain 90 percent water.

BEETS



Beets (*Beta vulgaris*) are native to the Mediterranean area of North Africa, Europe, and western Asia. The leaves have been eaten since before written history. The roots were used medicinally and didn't become a popular vegetable until French chefs began popularizing them in the 1800s. Beet powder has been used as a coloring agent in many foods, including the tomato sauce used on frozen pizzas.

Among beet cultivars, there is much room for personal preference. The roots may be round, flat, or elongated. Most are red or purple, but several other colors are now available as a result of modern breeding efforts. It is best to select cultivars that mature in 55 to 65 days.

Growing suggestions

Beets are cool-weather biennials that are grown as annuals for their leaves and roots. They produce the best quality when grown in cool soil and full sun.

As beets grow and the roots start to bulge out of the soil, it may be advisable to hill soil around them. Keeping the roots covered with soil will protect texture and color.

Soil type and soil preparation

Beet roots develop the best shape and color in light or organic (peat) soils. However, they will grow in almost any good soil that has a good quantity of organic matter. Add organic matter if needed, preferably in the fall. Till to mix crop residues and organic matter into the top 7 to 8 inches of soil. Create a fairly deep, mellow (soft) seedbed to prevent compaction around the developing roots. Avoid working soil when it is too wet.

Planting

Sow beet seeds 2 to 4 weeks before the average last spring frost, when the soil temperature is approaching 50°F. If a continual supply is desired, plantings can be made every 2 weeks until midsummer. Soak beet seeds in water overnight before planting to hasten germination. Beets can be planted in banded rows or in non-row groupings; give each plant about 6 to 8 square inches of space.

Planting specifications:

- Seed spacing: 0.5–0.75 inch
- Final spacing: 2–3 inches
- Ounces of seed per foot: 0.01
- Row width: 12–18 inches
- Seed depth: 0.5–1 inch
- Germination: 10–15 days

Fertilizer

Beets require very little fertilizer. All of the fertilizer can be applied during soil preparation. A 5-10-10 or similar fertilizer formulation is usually adequate. Add the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet.

Weed control

Beets require full-season weed control because they are never fully competitive with weedy plants. Shallow cultivation should be used when necessary, as deep cultivation close to the plants can damage the root system, reducing yield and quality. A general garden herbicide can be effective in limiting weed populations.

Irrigation

Shallow planting and problems with soil crusting mean that beets may need several light irrigations to ensure good seedling emergence. Once emerged, beets will do fine with any irrigation regime that maintains consistent soil moisture. Apply 1.5 to 2 inches of water every 5 or 6 days on most soils.

Insects

Beets can be damaged by several species of caterpillars, leafminers, and aphids. However, in most garden situations, beets can withstand these minor infestations without significant control measures.

Diseases

In Idaho gardens, beets may show mild symptoms of powdery mildew. This disease seldom requires control measures. Curly top virus, expressed as mottled or malformed leaves, may appear. Remove infected plants to minimize spread to healthy plants.

Harvest

Beet leaves can be harvested and used as a potherb at any time during the growing season. Beet roots can be harvested as soon as they are large enough to use. Roots are ready to be harvested 8 to 9 weeks after seeds are sown and are most tender when less than 2 inches in diameter. Harvest before roots become woody. Pull the beet and cut off the tops about 1 to 1.5 inches above the crown.

Storage

With tops removed, beets will keep for several months under refrigeration (just above freezing) with high humidity.

Consumptive yield

Compute household planting requirements as follows:

- 7–12 lb fresh beets per person
- 12–30 lb canned or frozen beets per person
- Each foot of row will yield 1.25 lb.

Plant 6 to 34 feet of row per person.

Nutritive value. Beets, especially dark red ones, are very high in antioxidants, compounds shown to lower cancer risk, improve memory, and reduce the effects of aging. They are an excellent source of folate and potassium and a good source of vitamin C, vitamin B6, iron, manganese, phosphorus, and copper. One hundred grams (3.5 oz) of raw red beets contain 43 calories, 1.6 grams of protein, 0.2 gram of fat, 9.6 grams of carbohydrates, and 2.8 grams of dietary fiber. Beet roots are made up of 88 percent water.

BROCCOLI



Broccoli (*Brassica oleracea*) is native to the Mediterranean area, where it probably was developed from a wild cabbage species by the ancient Etruscans. The Italians seem to be the first group of people to develop a real interest in broccoli. When introduced into England, it was called “Italian asparagus.” Broccoli was brought to America by immigrants, but didn’t become a popular vegetable in the United States until the 1920s.

Many outstanding cultivars of broccoli are available for garden production. Newer hybrid cultivars often have very large, high-quality heads that mature uniformly. Some of the older open-pollinated cultivars produce multiple crops by reheading after harvest. These secondary heads are often small but provide a continuous supply for table use.

Growing suggestions

Broccoli can be planted as seed, but there are many advantages to using transplants. Transplanting makes weed control easier, reduces seedling disease and insect problems, and improves quality by allowing harvest before hot weather sets in. Broccoli plants are easy to transplant, as long as the seedlings are hardened off before being placed in the garden.

Soil type and soil preparation

Broccoli will grow in most soils, from sand to clay. Prepare the seedbed when the soil has sufficient moisture to form a ball that crumbles into medium-size fragments under finger pressure. Broccoli quality will be enhanced by working in large amounts of organic matter.

Planting

Broccoli can be direct seeded up to 4 weeks prior to average last frost. Direct seeding is recommended

only for areas with a relatively long, cool spring season that will allow the broccoli to mature before summer heat sets in. Plant seeds 0.5 inch deep. With proper moisture, germination will occur in 3 to 10 days.

In most of Idaho, broccoli performs best if transplanted. Broccoli can be transplanted 2 to 4 weeks before average last spring frost. Transplants should be stocky, have a stem about the diameter of a pencil, and be dark green and vigorous. Overly large or weak transplants will not produce large, quality heads. New transplants may require protection from wind and extreme frost events (below 25°F).

To produce your own transplants, sow broccoli seeds indoors 5 to 7 weeks prior to the predicted transplant date. Before setting the transplants into the garden, harden them off by setting them outside for increasing periods of time during the last 1 or 2 weeks of growth.

Transplanting specifications:

- Final spacing: 18–24 inches
- Row width: 24–30 inches

Fertilizer

Broccoli is a heavy feeder and responds positively to adequate levels of N, P, and K. Split applications work best to keep broccoli growing vigorously through harvest. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or similar nutrient ratios) is usually appropriate. Sidedress an additional 0.25 lb N when the plants are about 12 inches tall. For sidedressing, select a high-N fertilizer such as 21-0-0 or 46-0-0.

Weed control

Early-season weed control is important for broccoli. Once established, plants compete fairly well with weeds. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. When tilling close to plants, tillage should be shallow in order to prevent damage to roots. Also, try to avoid damaging the large, brittle leaves of mature plants.

Irrigation

Drought stress has a marked effect on broccoli quality, making heads fibrous and strong flavored. It is important to provide consistent, timely irrigation. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1 to 1.5 inches of water every 3 to 5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Common broccoli pests in Idaho include aphids, cabbage worms, cabbage loopers, and cutworms. Aphids can be washed from the plant using a hard stream of water. Serious infestations may require the use of a labeled insecticide. Cabbage worms and cabbage loopers damage both the leaves and the heads. Cabbage worms often inhabit the heads and become evident only upon cooking. They may require an insecticidal product for good control. Early transplanting often allows harvest before cabbage worms and loopers become a problem. Cutworms often kill new transplants by chewing them off at ground level. Placing small cardboard collars around the base of the plants often prevents this problem.

Diseases

There are no consistent, serious diseases of broccoli in Idaho gardens.

Harvest

Harvest broccoli when the center head is 4 to 10 inches across. However, head size is not the critical factor in determining maturity. Harvest when heads reach maximum size but are still compact and dark green, as heads quickly lose quality once the buds start to separate and turn yellow. Harvest by cutting the stem 3 inches below the flower buds. Utilize both the stem and the head. After the first harvest, broccoli often produces small lateral heads. If the central head becomes overly mature, remove it to stimulate production of these side shoots.

Storage

Broccoli head quality deteriorates very quickly following harvest. Broccoli is rarely stored and should be prepared or processed immediately after harvest. If necessary, it can be held for a few days at near-freezing temperatures in a moist refrigerator.

Consumptive yield

Compute household planting requirements as follows:

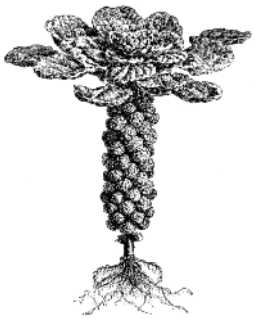
- 3–5 lb fresh broccoli per person
- 5–6 lb frozen broccoli per person
- Each foot of row will yield 0.75 lb.

Plant 4 to 15 feet of row per person.

Nutritive value

Broccoli is remarkably nutritious. It contains many phytonutrients, including thiocyanates, indoles, sulforaphane, isothiocyanates, and flavonoids, which help prevent prostate, colon, urinary tract, pancreatic, and breast cancers. Broccoli is an excellent source of vitamin C and vitamin K. It is a good source of thiamin, riboflavin, folate, vitamin E, vitamin B6, magnesium, manganese, iron, phosphorus, and potassium. One hundred grams (3.5 oz) of broccoli (head or bud clusters, stems, and leaves) contain 31 calories, 2.8 grams of protein, 0.4 gram of fat, 6.6 grams of carbohydrates, and 2.6 grams of dietary fiber. Broccoli heads contain about 89 percent water.

BRUSSELS SPROUTS



Brussels sprouts (*Brassica oleracea*) originated in Europe, principally in Brussels, Belgium. They are considered to be one of the "newer" vegetables, having been cultivated for only about 400 years. They were first described in the literature in 1587. By 1800, they were commonly grown in Belgium and France. Some people were growing Brussels sprouts in the United States by 1800, but they have never become widely popular in this country.

Brussels sprouts resemble small cabbages but require a longer growing season than cabbage. There are two major classes of Brussels sprouts, dwarf and tall. The dwarf types mature in fewer than 100 days and are best for the cooler regions of Idaho. The tall types require up to 100 days to mature and are suitable for the warmer areas of the state.

Growing suggestions

Brussels sprouts are best planted as transplants. Transplanting makes weed control easier and reduces seedling disease and insect problems. Brussels sprouts are easy to transplant, as long as the seedlings are hardened off before being placed outside in the garden.

Late in the season, tall plants may become susceptible to damage from wind. Prevent plants from tipping over by installing support stakes.

Soil type and soil preparation

This vegetable is adaptable to various soil types, as long as the soil is fertile, has good texture, and is moist. Brussels sprouts quality is enhanced by incorporating large amounts of organic matter.

Planting

If producing your own transplants, sow seeds in containers 4 to 6 weeks before transplanting in the garden. Otherwise, purchase transplants that are stocky, healthy, and not too large (stems the diameter of a pencil). Place them in the garden 2 to 4 weeks before average last frost. Protect them from wind and hard frost for the first 1 or 2 weeks.

Transplanting specifications:

- Final spacing: 18–24 inches
- Row width: 24–30 inches

Fertilizer

Brussels sprouts require high levels of fertility. Split applications of N work best to keep Brussels sprouts growing vigorously through final harvest. A preplant fertilizer application of 0.2 lb N for each 100 square feet is recommended. A 10-10-10 fertilizer formulation (or similar nutrient ratios) is usually appropriate. When plants are about one-third their final height, sidedress with an additional 0.2 lb N per 100 square feet. For sidedressing, select a high-N fertilizer such as 21-0-0 or 46-0-0.

Weed control

Early-season weed control is important for Brussels sprouts. Once established, plants compete fairly well with weeds. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. As Brussels sprouts approach maturity, tillage close to plants should be shallow in order to prevent damage to roots. Also, it is important not to damage the large, brittle leaves of mature plants.

Irrigation

Good flavor and tenderness of Brussels sprouts depend on proper irrigation and consistent soil moisture. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1 to 1.5 inches of water every 4 or 5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Common pests of Brussels sprouts in Idaho include aphids, cabbage worms, cabbage loopers, and cutworms. Aphids can be washed from the plant using a hard stream of water. Serious infestations may require the use of a labeled insecticide. Cabbage worms and loopers damage leaves, but are a serious problem only if they partially defoliate the plants. They can be removed by hand or may require an insecticidal product for control. Cutworms often kill new transplants by chewing them off at ground level. Placing small cardboard collars around the base of the plants often prevents this problem.

Diseases

Serious diseases of Brussels sprouts in Idaho gardens are rare.

Harvest

As the sprouts on the main stem begin to enlarge, remove the lower leaves of the plant. Harvest sprouts as they become solid and about 1 to 2 inches in diameter. The lowest sprouts will mature first. To speed up sprout maturity, pinch off the tip of each plant in late August or early September; however, this may reduce the total yield of the plant by as much as one-third. Brussels sprouts can withstand cold fall temperatures, and the best tasting sprouts are those that mature after the first fall frost.

Storage

When nighttime temperatures drop to 20°F on a regular basis, dig up the plants with a little soil remaining around the roots. Put them into a deep cold frame or in an unheated dark garage. They will continue to grow until all the sprouts mature.

Harvested Brussels sprouts can be stored for 2 to 3 weeks in a refrigerator at a temperature near freezing and with high humidity. They should not be stored with apples or other fruits because they may become bitter due to the presence of a gaseous compound called ethylene.

Consumptive yield

Compute household planting requirements as follows:

- 1.5–4 lb fresh Brussels sprouts per person
- 4–6 lb canned or frozen Brussels sprouts per person
- Each foot of row will yield 0.5 lb.

Plant 3 to 20 feet of row per person.

Nutritive value

Brussels sprouts are an outstanding source of vitamin K, which is linked to bone health. They are also an excellent source of vitamin C and a good source of thiamin, folate, riboflavin, vitamin E, vitamin B6, iron, magnesium, manganese, phosphorus, and potassium. One hundred grams (3.5 oz) of Brussels sprouts provide 3.4 grams of protein, 0.3 gram of fat, 9 grams of carbohydrates, 43 calories, and 3.8 grams of dietary fiber. Fresh Brussels sprouts are 86 percent water.

CABBAGE



The wild relatives of the cabbage plant are native to the Mediterranean area of Europe. These nonheading types of cabbage were cultivated for thousands of years before people began to prefer the smaller, tender leaves packed more closely in the center of certain plants. Initially, people had gravitated toward plants with large, succulent leaves. They chose these plants as their source of seed for the next year. Kale was developed by the 5th century B.C. Later, selection began for small, tender leaves, and over time plants began to emerge that had cluster or "head" formation. By the 1st century A.D., cultivated cabbage (*Brassica oleracea*) looked much like the plants we grow today.

Cabbage cultivars vary widely. Maturity times vary, and heads may be globular or flat; smooth or savoy; and green, red, or purple. Some cultivars produce heads that will store for many months under proper conditions. Choose cultivars based on personal preferences and growing conditions.

Growing suggestions

Cabbage can be either transplanted or direct seeded. Transplanting is best in short-season areas. Also, transplanting makes weed control easier and reduces seedling disease and insect problems. Cabbage is easy to transplant, as long as the seedlings are hardened off before being placed outside in the garden.

To achieve best quality, cabbage must be supplied with consistent growing conditions. Any fluctuation in rate of growth, caused by stress, nutrient deficiencies, or lack of water, can cause the heads to split.

Soil type and soil preparation

Cabbage is adaptable to various soil types, as long as the soil is fertile, has good texture, and is moist. Begin seedbed preparation when the soil has sufficient moisture to form a ball that crumbles into medium-size fragments under finger pressure. Cabbage quality is enhanced by working in organic matter.

Planting

If direct seeding, plant extra seeds and thin to a final stand. Plant cabbage 3 to 5 weeks prior to average last frost or as soon as the soil is dry enough to be worked.

Transplants can be purchased or grown from seed. If producing your own transplants, sow seeds into containers 4 to 6 weeks before transplanting to the garden. Otherwise, purchase transplants that are stocky, healthy, and not too large. (Stems should be the diameter of a pencil.) Large cabbage transplants may bolt (produce seed stalks instead of heads) if subjected to several weeks of 40° to 50°F weather. Transplant to the garden 2 to 4 weeks before average last frost.

Planting specifications:

- Seed spacing: 1.25–1.5 inches
- Final spacing: 1–2 feet
- Ounces of seed per foot: 0.01
- Row width: 24–30 inches
- Seed depth: 0.25–0.5 inch
- Germination: 4–10 days

Transplanting specifications:

- Final spacing: 18–24 inches apart

Fertilizer

Cabbage is a heavy nutrient user and needs a good supply of most nutrients, especially N, P, and K. Split applications work best to keep cabbage growing vigorously through harvest. Apply 0.25 lb N (in combination with P and K) per 100 square feet before planting. A 10-10-10 fertilizer formulation (or similar nutrient ratios) is usually appropriate. Sidedress an additional 0.25 lb N, using a 21-0-0, 46-0-0, or similar high-N fertilizer, when the plants show signs of heading.

Weed control

Early-season weed control is important. Once established, plants compete well with weeds. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Once plants reach full size, tillage activities close to plants should be shallow in order to prevent damage to roots. Also, avoid damage to the large, brittle leaves of mature plants.

Irrigation

Head size and tenderness depend on proper irrigation and consistent soil moisture. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1 to 1.5 inches of water every 3 to 5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Common pests of cabbage in Idaho include aphids, cabbage worms, cabbage loopers, and cutworms. Aphids can be washed from the plant using a hard stream of water, although they may crawl under the outer leaves of the head, where they are difficult to reach. Heavy infestations may require use of a labeled insecticide. Cabbage worms and loopers usually do the most damage to the outer leaves of the head and are a serious problem only if they consume large portions of the outermost layer. They can be removed by hand or may require an insecticidal product for control. Cutworms often kill new transplants by chewing them off at ground level. Placing small cardboard collars around the base of the plants often prevents this problem.

Diseases

There are few, if any, serious diseases of cabbage in Idaho gardens.

Harvest

Cabbage is ready to harvest 50 to 65 days after transplanting. The heads should be solid, but must be picked before they crack. Soft heads have poor quality. Heads may split during hot weather if the water supply fluctuates.

Reducing irrigation or twisting the mature heads part of the way around to sever half the roots will allow mature cabbage to stay in the garden longer without losing quality. Plants harvested early in the summer and left with as many leaves as possible often develop small heads where the leaves meet the stem. These heads are edible and should be picked when firm.

Cabbage can withstand very light frosts before harvest. However, temperatures below 30°F may result in injury that will eventually cause the head to break down.

Storage

For storage, place mature cabbage heads in a pit, trench, outdoor cellar, or cool storage room. The temperature should be as near 32°F as possible, and definitely 40°F or below. Humidity should be high. Stored cabbages will last well into winter.

Consumptive yield

Compute household planting requirements as follows:

- 4–5 lb fresh cabbage per person
- 6–12 lb processed cabbage per person
- Each foot of row will yield 0.8 lb.

Plant 5–21 feet of row per person.

Nutritive value

Cabbage contains thiocyanates, indoles, sulforaphane, isothiocyanates, and flavonoids, which help prevent cancer and lower "bad cholesterol." It is an excellent source of vitamin C and vitamin K, as well as a good source of thiamin, vitamin B6, folate, iron, and manganese. One hundred grams (3.5 oz) of cabbage supply 1.3 grams of protein, 0.1 gram of fat, 5.8 grams of carbohydrates, 25 calories, and 3.8 grams of dietary fiber. Fresh cabbage consists of 92 percent water.

CANTALOUPES



Evidence exists that cantaloupes (*Cucumis melo*) were cultivated from Egypt to Iran and northern India as early as 2400 B.C. Dried and roasted melon seeds have been a favorite throughout the Middle East and China for several thousand years. During the 15th century, Arabs brought melon seeds to southern Spain, where the fruit became popular. From there, Columbus took them on his second voyage to the New World, and they were planted in Haiti. Cantaloupes were soon being grown in Central and South America, where the native populations enjoyed the new fruit. By the 1600s, cantaloupes were being grown in parts of North America. They didn't become a popular crop in the United States, however, until after the Civil War.

Most cantaloupe cultivars are suitable for production in the south-central and southwestern regions of Idaho. In all other areas, it is important to select early-maturing cultivars. In short-season areas, early cultivars of standard netted muskmelons may mature to a quality harvestable state. Most crenshaw, cassava, honeydew, or Christmas-type melons require a longer season than is usually available.

Growing suggestions

Cantaloupe plants have separate male and female flowers on the same vine and are cross pollinated. For this reason, they need insects to pollinate the flowers. It is important to protect pollinators in the garden when growing cantaloupes.

Cantaloupes require full sun all day long to produce the sweetest fruit. Any shade will not only result in inferior flavor, but may delay maturity, making production in marginal climates even more difficult.

Cantaloupes are a warm-season crop. It is critical to be patient in waiting for warm, late-spring weather before planting them in the garden. It helps to provide warm growing conditions by planting next to a south-facing structure, planting on black plastic, and/or using row covers.

Soil type and soil preparation

Cantaloupes are adapted to most soils, but grow best in a fertile, mellow soil with large amounts of compost. During tillage, incorporate organic matter, if needed. Cantaloupes will grow faster and mature earlier in sandy soils.

Planting

Cantaloupes can be either direct seeded or transplanted. Direct seeding usually results in healthier, stronger plants. Transplanting often provides the advantage of slightly earlier maturity. Direct seed 1 to 2 weeks after average last frost and when daytime maximum soil temperatures are near 70°F.

Transplanting cantaloupes into the garden requires special attention to details. Use transplants that are healthy and at the right stage of growth. Transplants that are too old, etiolated ("spindly"), slow-growing, or have been stressed at any time for water or nutrients seldom produce a vigorous plant. A root-hardening response common to this family of plants slows or prevents new growth on less-than-ideal transplants. Acceptable transplants have only one or two true leaves (don't count cotyledons), are succulent and growing rapidly, have dark green color, and are short and compact.

Timing of transplanting is usually 2 to 3 weeks after average last frost and only when the forecast is for mild weather. Once a healthy transplant has been placed in the garden, it must be protected from intense sunlight, wind, and near-freezing or freezing temperatures.

Planting specifications:

- Seeds per hill: 3–5
- Distance between hills: 3–4 feet*
- Final stand per hill: 2–3 plants
- Ounces of seed per foot: 0.05
- Row width: 4–6 feet
- Seed depth: 1 inch
- Germination: 5–14 days

**Hill spacing for transplants is the same as for seed.*

Fertilizer

Cantaloupes are heavy feeders and respond positively to adequate levels of N, P, and K. Split applications work best to keep cantaloupes growing vigorously throughout the season. Add the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or similar nutrient ratios) is usually appropriate. Sidedress an additional 0.3 lb N (21-0-0, 46-0-0, or similar formulation) at the time the plants begin to form running vines.

Weed control

Cantaloupes do not compete well with weeds at any stage of growth. Consequently, season-long weed control is required. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. At all stages of growth, tillage activities close to plants should be shallow in order to prevent damage to roots. Avoid damage to the vines during weed-control efforts.

Irrigation

Cantaloupes require average amounts of water as compared to other crops. They produce the sweetest melons if not over-irrigated during the latter part of the season. Once plants are established and growing, applications of 1.5 to 2 inches of water every 5 or 6 days are usually adequate. On very sandy soils, you may need to supply water more frequently.

Insects

Cutworms are a common pest of cantaloupes in Idaho. They emerge from the soil at night and cut down newly emerged seedlings or transplants. Consistent problems with cutworms may require application of a labeled soil insecticide. Spider mites occasionally become problematic. They are best controlled by using sprinkler irrigation because they tend to avoid leaves that are frequently wet. Occasionally, an application of a miticide may be necessary.

Diseases

Repeated production of watermelons, cucumbers, cantaloupes, and squash can result in the buildup of a soil-borne disease called fusarium wilt. This fungus causes plants to remain small, become weak, turn yellow, develop burned leaf edges, and eventually die early. Crop rotations of at least 4-year intervals provide partial control. Cantaloupes are also very susceptible to root rots that result from poor soil drainage or over-irrigation.

A few viral diseases occasionally appear on cantaloupes. Symptoms include malformed leaves and fruit, mosaic color patterns on the leaves, and general yellowing or stunting. Plants showing these

symptoms should be removed to prevent them from competing with healthy plants.

Powdery mildew, identified by white, powdery fungal growth on the upper leaf surface, often appears in Idaho gardens. No control is necessary if it appears during the last month of the season because it will do little or no damage to the crop. If it appears earlier, it may be necessary to apply a labeled garden fungicide.

Fruit rots can occur if melons sit on damp soil for extended periods of time. Prevent this problem by irrigating properly and by planting on plastic mulch or suspending the developing fruit above the soil.

Harvest

Cantaloupes must ripen on the vine for maximum quality. Ripe netted cantaloupes form an abscission layer where the stem meets the fruit, allowing the fruit to separate from the vine when it is ripe. When the stem is nearly loose, the cantaloupe is said to be at the full slip stage and is ready to be harvested. Slight softening of the blossom end, a change in the background color of the melon from green to yellow or tan, and a strong cantaloupe smell are additional indications of ripeness.

Storage

Cantaloupe fruits can be held for a few days at room temperature. Held for too long, they quickly soften and become susceptible to fruit rots.

Consumptive yield

Compute household planting requirements as follows:

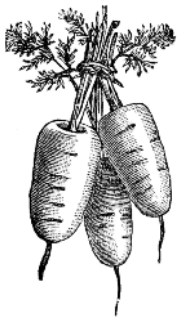
- 8–10 lb fresh cantaloupe per person
- Each foot of row will yield 1 lb.

Plant 8–10 feet of row per person.

Nutritive value

Cantaloupes are very high in vitamin A, which is a powerful antioxidant, protects vision, and helps maintain healthy mucus membranes and skin. They are also an excellent source of vitamin C and a good source of niacin and vitamin B6. One hundred grams (3.5 oz) of cantaloupe contain 1.8 grams of protein, 0.2 gram of fat, 8.2 grams of carbohydrates, 34 calories, and 0.9 gram of dietary fiber. Fresh cantaloupe fruits are 90 percent water.

CARROTS



The use of carrot roots (*Daucus carota*) as food began about 5,000 years ago in the area now known as Afghanistan. Drawings found in Egyptian pyramids from about 2000 B.C. show what seem to be purple carrots. Early Egyptian writings discuss various medical treatments using carrots and carrot seeds. By the 10th century, Arab merchants traveling throughout Arabia, Asia, and Africa brought home the seeds of purple carrots. Other early carrot cultivars consisted of a range of colors such as purple, white, light yellow, green, red, and almost black.

Purple and yellow varieties are believed to have been brought to southern Europe in the 12th century by Moorish invaders. By the 13th century, carrots were being grown in German and French farms and gardens. Flemish refugees brought various colors of carrots to England in the 15th century. It wasn't until the 1500s that Dutch plant breeders used mutant yellow carrot seeds to develop an orange cultivar. With continued improvements, the orange carrot was made sweeter, and its popularity spread.

Soil type and soil preparation

Carrots grow best in loose loamy, sandy, or organic soils. Heavy clay soils can cause misshapen roots, but this problem can be improved by the addition of organic matter. For an ideal seedbed, create a 12-inch-deep mixture consisting of one-fifth garden soil, two-fifths sand, and two-fifths compost or peat moss. Spring application of manure to carrots often results in branched, short, or malformed roots. If you apply manure, it is best to do so in the fall. Applications in the spring must be light, using only well-aged manure. Soil tillage must be deep and create a mellow seedbed. Avoid working overly wet soil, which may become compacted and cloddy. Before planting, rake the soil surface to create a smooth, firm surface.

Planting

Plant carrots up to 2 weeks prior to the average last killing frost and when daytime soil temperatures approach 50°F. A salt or pepper shaker can be used to scatter seeds in the row. In small gardens, carrots

can be grown in banded rows or groupings in raised beds.

Because carrots require shallow planting, the soil often dries out and crusts, making it difficult for seedlings to emerge. Keeping the soil moist after planting is critical. It may be necessary to irrigate lightly several times a day until seedlings emerge. Other methods for maintaining soil moisture and preventing crusting include covering seeds with a light layer of compost, (sifted) grass clippings, sawdust, or vermiculite. Clear plastic or damp burlap placed over the seedbed will also speed germination by warming the soil, preventing crusting, and keeping the soil moist. Remove the cover as soon as the seedlings emerge.

Coplanting carrots and radishes often helps carrots overcome soil crusting issues and provides a good stand. Once the radishes are harvested (pull carefully to avoid damaging the carrots), the carrots will be well spaced and off to a good start.

As the carrots grow, thin them to 1 to 2 inches apart in the row. In group plantings, thin to provide 3 to 4 square inches per plant.

Planting specifications:

- Seed spacing: 0.5–0.75 inch
- Final spacing: 1–2 inches
- Ounces of seed per foot: 0.02
- Row width: 15–24 inches
- Seed depth: 0.25–0.5 inch
- Germination: 10–17 days

Fertilizer

Carrots require only moderate levels of fertilizer to produce an acceptable crop. All fertilizer applications for carrots can be made during soil preparation. A 10-10-10 or similar fertilizer formulation is usually appropriate. The equivalent of 0.25 to 0.3 lb N (in combination with P and K) per 100 square feet will provide adequate levels of nutrients.

Weed control

Carrots require early-season weed control, but compete well with weeds once full size. Cultivation or use of a labeled garden herbicide can limit weed populations.

Irrigation

Shallow planting and problems with soil crusting mean that carrots may need several light irrigations to ensure good seedling emergence. Once emerged, any irrigation regime that maintains consistent soil moisture is adequate. Carrots tolerate a wide range of soil moisture conditions, as long as they do not get dry enough to cause wilting. Application of 1.5 to 2 inches of water every 5 or 6 days will work on most soils.

Insects and other pests

In Idaho, carrots have few serious insect problems, other than occasional soil pests such as wireworms or carrot rust flies. Carrot rust fly larvae tunnel into and damage the roots. If this is a consistent problem, remove all carrot residue from the garden after harvest and avoid the practice of overwintering carrots in the ground.

Root-knot nematodes (microscopic wormlike creatures) can be a serious pest of carrots. They cause the roots to be bumpy and deformed, with a proliferation of tiny feeder roots. Nematodes are very difficult to manage or control. The best advice is to avoid growing a garden in infested soils. If this is not feasible, crop rotation will help minimize damage.

Diseases

Powdery mildew, identified by a white, powdery fungal growth on the upper leaf surface, is an occasional problem with carrots in Idaho gardens, but it seldom requires control. Although not common, aster yellows occasionally becomes problematic. It is caused by a bacteria-like organism. Infected plants are stunted and yellow, and the roots become “hairy” due to the growth of many secondary roots. There is no cure for this disease. If infected plants are found, it is best to remove and destroy them to prevent spread to healthy plants.

Harvest

Carrots can be harvested as soon as the roots are the size of a little finger. Beginning harvest early allows for a long harvest window. The highest quality roots are harvested after fall frost when the carrots become sweeter.

Storage

Carrots can be stored throughout the fall and winter in a pit, storage cellar, refrigerator, or covered row. Once out of the soil, carrots store best if the tops are removed. Storage temperature should be as near 32°F as possible. Maintain high humidity.

Consumptive yield

Compute household planting requirements as follows:

- 5–10 lb fresh carrots per person
- 10–25 lb canned or frozen carrots per person
- Each foot of row will yield 1 lb.

Plant 5 to 35 feet of row per person.

Nutritive value

Carrots contain the antioxidant falcarinol, which may have anti-cancer properties. Carrots are well-known as an excellent source of vitamin A. They are also a good source of niacin, thiamin, vitamin B6, folate, vitamin C, vitamin K, manganese, phosphorus, and potassium. One hundred grams (3.5 oz) of raw carrots provide 0.9 gram of protein, 0.2 gram of fat, 9.6 grams of carbohydrates, 41 calories, and 2.8 grams of dietary fiber. Fresh carrots are 88 percent water.

CAULIFLOWER



Cauliflower (*Brassica oleracea*) probably originated in Asia Minor in the 15th century, but was used almost exclusively in Italy until the 16th century. At that time it was introduced into France and eventually became a part of diets throughout Europe. Cauliflower came into common use about a century before broccoli, but wasn't grown in North America until the late 1600s.

There are many outstanding cultivars of cauliflower available for garden production. Newer hybrid cultivars include those that are self-blanching, meaning they produce leaves that are folded over the head to keep curds white, flavorful, and attractive.

Growing suggestions

Cauliflower is considered the most delicate member of the cabbage family. It can be difficult to grow because it requires cool temperatures, constant moisture, and high levels of fertility. In hot weather, cauliflower will not head up well, and it is less tolerant of cold fall temperatures than cabbage.

Cauliflower is typically transplanted rather than grown from seed. There are many advantages to using transplants, including simpler weed control, fewer seedling disease and insect problems, and improved earliness. Early cauliflower usually has better quality because it is harvested before the arrival of hot summer temperatures. Cauliflower plants are easy to transplant, as long as the seedlings are hardened off before being placed in the garden.

If growing a cultivar that is not self-blanching, it is essential to protect developing curds from sunlight to maintain white color and good eating quality. The most common method is to tie the largest inside leaves over the heads. Large rubber bands work well to secure the blanching leaves.

Soil type and soil preparation

Cauliflower grows well in most soils, from sand to clay. It does well in Idaho soils that have been modified with extra organic matter. Soil preparation should include the addition of organic matter in the form of manure or compost.

Planting

Transplanting is the best way to establish cauliflower in Idaho. Transplant cauliflower 2 to 3 weeks before average last spring frost. At the time of planting, transplants should not be too large. They should be stocky, have a stem about the diameter of a pencil, and be dark green and vigorous. Overly large or weak transplants will not produce large, quality curds.

To produce your own transplants, sow cauliflower seeds indoors 5 to 7 weeks before the expected transplanting date. Before setting the transplants into the garden, harden them off by setting them outside for increasing periods of time during the last 1 or 2 weeks of growth.

Transplanting specifications:

- Final spacing: 18–24 inches
- Row width: 24–30 inches

Fertilizer

Cauliflower is a heavy feeder and responds positively to adequate levels of N, P, and K. Split applications of N work best to keep cauliflower growing vigorously through harvest. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or similar ratios) is

usually appropriate for this preplant application. Sidedress an additional 0.25 lb N (21-0-0, 46-0-0, or similar product) when the curds begin to develop.

Weed control

Early-season weed control is important for cauliflower. Once established, plants compete fairly well with weeds. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. At all stages of growth, tillage activities close to plants should be shallow in order to prevent damage to roots. Also, try to avoid damage to the large, brittle leaves of mature plants.

Irrigation

Improper irrigation detracts from cauliflower curd quality, making curds fibrous and strong flavored. It is important to provide consistent, timely irrigation. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1 to 1.5 inches of water every 3 to 5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Common cauliflower pests in Idaho include aphids, cabbage worms, and cutworms. Aphids can be washed from the plant using a hard stream of water. Serious infestations may require the use of a labeled insecticide. Cabbage worms damage both the leaves and the curds. They often inhabit the curds and become evident only upon cooking. They may require an insecticidal product for good control. Early planting often allows harvest before cabbage worms become a problem. Cutworms often kill new transplants by chewing them off at ground level. Placing small cardboard collars around the base of the plants often prevents this problem.

Diseases

There are few or no serious diseases of cauliflower in Idaho gardens.

Harvest

Harvest cauliflower when the curd is 4 to 8 inches across, bright white, and compact. Once the curd becomes loose, called ricing, quality quickly declines.

Storage

Cauliflower can be stored for a longer period than broccoli, up to a week or more if held at near-freezing temperatures and high humidity. Quality for freezing is best if processing occurs soon after harvest.

Consumptive yield

Compute household planting requirements as follows:

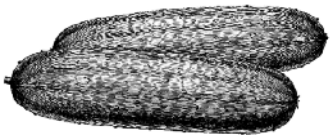
- 3–5 lb fresh cauliflower per person
- 8–12 lb frozen cauliflower per person
- Each foot of row will yield 1 lb.

Plant 3–17 feet of row per person.

Nutritive value

Cauliflower is a nutritious food. Along with many of the brassica crops, it contains di-indolyl-methane, which serves to enhance the immune system. Cauliflower is an excellent source of vitamin C and a good source of folate, vitamin B5, vitamin B6, vitamin K, iron, manganese, phosphorus, and potassium. One hundred grams (3.5 oz) of cauliflower curds contain 1.9 grams of protein, 0.3 gram of fat, 5 grams of carbohydrates, and 25 calories. Fresh cauliflower curds are 92 percent water.

CUCUMBERS



It is believed that cucumbers (*Cucumis sativus*) are native to India and likely have been cultivated in western Asia for more than 3,000 years. The Romans probably introduced this vegetable to Europe. Agricultural records show that the French were cultivating cucumbers in the 9th century, and by the 14th century they were being grown in English gardens and farms. Cucumbers didn't arrive in North America until Columbus brought them in the late 15th century.

Growing suggestions

Cucumbers can be planted with cantaloupes, watermelons, and squash without fear of cross pollination. The flavor of cucumbers is not affected by the pollen from these related crops.

Cucumber plants have separate male and female flowers on the same vine and are cross pollinated. For this reason, they need insects to pollinate the flowers and produce fruit. It is important to protect pollinators when growing cucumbers.

Cucumbers do best where they will receive at least 8 hours of sunlight daily.

It is essential to pick fruits every day or every other day to maintain plant productivity. Once cucumber fruits reach mature size with fully developed seeds, they send a hormonal signal to the plant to stop production of new fruits.

Soil type and soil preparation

Cucumbers are adapted to most soils, but grow best in a fertile, mellow soil with large amounts of compost. During tillage, incorporate organic matter, if needed. Cucumbers grow faster and mature earlier in sandy soils.

Planting

Cucumbers can be either direct seeded or transplanted. Direct seeding usually results in healthier, stronger plants. Transplanting often provides the advantage of earlier maturity. Direct seed 1 to 2 weeks after average last frost and only when daytime soil temperatures are near 70°F.

If transplanting, use transplants that are healthy and at the right stage of growth. Transplants that are too old, etiolated, or slow-growing, and those that have been stressed at any time for water or nutrients, seldom produce a vigorous plant. Acceptable transplants have only one or two true leaves (don't count cotyledons) and are succulent, growing rapidly, dark green, short, and compact. Transplant 2 to 3 weeks after last average frost and only if the forecast is for mild weather. Once a healthy transplant has been placed in the garden, it must be protected from intense sunlight, wind, and near-freezing or freezing temperatures.

Planting specifications:

- Seeds per hill: 3–5
- Distance between hills: 3–4 feet*
- Final stand per hill: 2–3 plants
- Ounces of seed per foot: 0.05
- Row width: 4–6 feet
- Seed depth: 1 inch
- Germination: 6–10 days

Hill spacing for transplants is the same as for seed.

Fertilizer

Cucumbers respond well to adequate levels of soil nutrients. Split applications of N work best to keep cucumbers growing vigorously throughout the season. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or product with similar nutrient ratios) is usually appropriate. Sidedress an additional 0.3 lb N (21-0-0, 46-0-0, or similar product) at the time the plants begin to form running vines.

Weed control

Cucumbers do not compete well with weeds at any stage of growth. Consequently, season-long weed control is required. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. At all stages of growth, tillage activities close to plants should be shallow in order to prevent damage to roots. Avoid damage to the vines during weed-control efforts.

Irrigation

If plants are stressed for water, cucumber fruits become malformed and often develop a bitter flavor. Thus, it is important to supply consistent irrigation. Once plants are established, application of 1.5 to 2 inches of water every 5 or 6 days is usually adequate.

Insects

Cutworms are a common pest of cucumbers in Idaho. They emerge from the soil at night and cut down newly emerged seedlings. Repeated problems with cutworms may require application of a labeled soil insecticide prior to soil preparation.

Diseases

Production of watermelons, cucumbers, cantaloupes, and squash in the same site over multiple years can result in the buildup of a soil-borne disease called fusarium wilt. This fungus causes plants to remain small, become weak, turn yellow, develop burned leaf edges, and eventually die early. Partial prevention is possible by practicing crop rotation with at least 4-year intervals between these crops. Cucumbers are also very susceptible to root rots if over-irrigated or grown where there is poor soil drainage.

A few viral diseases occasionally occur on cucumbers. Symptoms include malformed leaves and fruit, mosaic color patterns on the leaves, and general yellowing or stunting. Plants showing these symptoms should be removed to prevent them from competing with healthy plants.

Powdery mildew, identified by white, powdery fungal growth on the upper leaf surface, often appears in Idaho gardens. No control is necessary if it appears during the last month of the season because it will do little or no damage to the crop. If it appears earlier, it may be necessary to apply a labeled garden fungicide.

Harvest

Harvest cucumbers any time after they have reached the desired size, but be sure to harvest before they turn yellow and the seeds become hard. For slicing, fruits should be 6 to 10 inches long. For pickles, harvest when fruits are 2.5 to 6 inches long. Cucumbers are of the highest quality when they are dark green, firm, and crisp.

Storage

If refrigerated, cucumbers can be held for several days. Sometimes seeds continue to develop in storage, reducing quality.

Consumptive yield

Compute household planting requirements as follows:

- 2.5–4 lb fresh cucumbers per person
- Each foot of row will yield 0.8 lb.

Plant 3–5 feet of row per person. Add additional row space for pickles as experience dictates.

Nutritive value

Cucumbers have a mild diuretic effect, which helps reduce weight and blood pressure. Due to their very high water content (95 percent), cucumbers rank as a good source of only a few nutrients, including vitamin A and vitamin K. One hundred grams (3.5 oz) of cucumbers with skins contain 0.7 gram of protein, 0.1 gram of fat, 3.6 grams of carbohydrates, 15 calories, and 0.5 gram of dietary fiber.

EGGPLANT



Eggplants (*Solanum melongena*) are native to India. They were also cultivated in southern and eastern Asia long before historical records were kept. The first known description of eggplant was found in an ancient Chinese agricultural record written in 544 A.D. All of the original eggplant names are of Arabic and North African origins, indicating that Arab cultures were primarily responsible for introducing eggplants to the Mediterranean region.

Most of the historically important varieties produced fruits that resembled goose or chicken eggs, were relatively small, and were white or light yellow.

Eggplants are in the Solanaceae family, and many people originally believed the plant was extremely poisonous. Over time, people learned that it was not only safe but a wonderful addition to many recipes.

Eggplant fruits vary greatly in size, shape, and color. They can be purple, green, white, or even orange. Some cultivars have mixed colors or color gradients. Size varies from 2-pound fruits to small, egg-size fruits. Some cultivars produce large, oval fruits, while others, such as the Chinese cultivars, produce fruits that are shaped like cucumbers. In India, miniature cultivars are quite popular.

Growing suggestions

Eggplants are best adapted to Idaho's warmest regions. However, they can be grown in some of the shorter season areas if provided with proper conditions. They benefit from full sun, a warm southern exposure, cold weather protection, black plastic mulch, and possibly row covers.

Soil type and soil preparation

Eggplants grow best in a rich soil with plenty of organic matter. Soils low in organic matter should be amended with compost or manure (added the previous fall, if possible). Work soil well to produce a deep, friable bed. Good soil tilth helps eggplants develop a healthy root system.

Planting

In Idaho, eggplants are almost always grown from transplants. Transplanting should occur 2 to 3 weeks after average last frost and after warm weather is the rule. At transplanting, the plants should be stocky and only 4 to 6 inches tall in order to minimize transplant shock.

It is feasible to produce your own transplants of eggplant. Doing so allows production of unusual varieties. Sow seeds in containers 10 weeks before the intended transplant date. The young plants tend to be very sensitive to transplant shock; therefore, it is best to plant two or three seeds in individual pots and thin to one plant by clipping off the weakest plants.

Transplanting specifications:

- Final spacing: 18–24 inches
- Row width: 24–36 inches

Fertilizer

Eggplants have a fairly high demand for nutrients over a long growing season. They do best with a balanced fertilizer program and respond to adequate levels of P and K. Add fertilizer in two separate applications. Add the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or similar nutrient ratios) is usually appropriate for preplant applications. Sidedress an additional 0.25 lb N when the plants are 12 inches high. For sidedressing, select a high-N source such as 21-0-0, 46-0-0, or product with similar high N formulation.

Weed control

Early-season weed control is important for eggplant production. Weeds can be controlled through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Once rapid growth begins, tillage close to plants should be shallow in order to prevent root damage. Once plants are tall, they often suppress weeds through competition and shading.

Irrigation

Once established, eggplants can get by on less water than many other vegetable crops. They develop an extensive fibrous root system. However, if they become severely stressed, fruit set will be curbed. Irrigate eggplants with 1.5 to 2 inches of water every 5 to 7 days.

Insects

Eggplants grown in Idaho can have problems with leaf-feeding insects. Colorado potato beetles and tomato hornworms can cause extensive defoliation. They can be controlled with an insecticide or by picking the larvae from the plants by hand. Aphids are an occasional problem and can be controlled by knocking them from the plants with a hard stream of water.

Diseases

Leaf spot diseases are common to eggplants in moister climates, but are seldom a problem in Idaho. Soil-borne diseases such as verticillium wilt make plants yellow and weak. Control these diseases by rotating eggplants and other solanaceous crops to different places in the garden each year.

Harvest

Eggplants can be harvested anytime after the fruits reach egg size. The quality of young fruit is better than that of older fruit. Be sure to harvest before the fruit reaches full maturity and the seeds harden. Leave a short stem on the fruit when harvesting. The stems are woody, so harvest with pruning shears. Keeping the fruits picked will stimulate additional production. Three or 4 weeks before the average first killing frost, clip or pinch off any remaining blossoms to encourage the plant to finish maturing the existing fruits.

Storage

Eggplant fruits cannot be refrigerated without suffering cold injury. Storage life at room temperature is limited to a few days.

Consumptive yield

Compute household planting requirements as follows:

- 3–5 lb fresh eggplant per person
- 2–3 lb canned or frozen eggplant per person
- Each foot of row will yield 1 lb.

Plant 3–8 feet of row per person.

Nutritive value

Eggplants contain a lower nutrient content than many other vegetables, but are still an important source of some vitamins and minerals. Research in Brazil has shown eggplants to be effective in treating high blood cholesterol. Fruits with purple skin also contain some anthocyanins with antioxidant activity. Eggplants are a good source of vitamin B5, vitamin B6, folate, and manganese. One

hundred grams (3.5 oz) of raw eggplant contain 1 gram of protein, 0.2 gram of fat, 5.7 grams of carbohydrates, 24 calories, and 3.4 grams of dietary fiber. Fresh eggplant fruits contain 92 percent water.

KOHLRABI



The edible portion of kohlrabi (*Brassica oleracea*) is an above-ground enlarged stem that resembles a mild turnip in shape and flavor. An excellent raw addition to relish dishes, it also may be boiled, stuffed, or baked.

Historians don't agree on the origin of kohlrabi. Historical records indicate that in the 1st century A.D., Pliny the Elder talked about what he called a "Corinthian turnip." Based on the description of this plant's growing habits, most historians agree that he must have been referring to kohlrabi. Apicius, a Roman citizen, wrote an early cookbook on Roman cooking and dining and includes this vegetable as an ingredient in some of his recipes.

By the 1600s, kohlrabi was being grown in northern India, where it became an important part of local diets. It is now common in China and Africa. In the United States, it continues to be a lesser known vegetable, but seems to be gaining in popularity. Cultivars vary in color, including white, green, and purple.

Growing suggestions

Growing kohlrabi is similar to growing many of the other cole crops such as broccoli, kale, and cauliflower. Kohlrabi develops best quality when grown in the cool weather of early spring or late fall.

Soil type and soil preparation

Kohlrabi grows in most soils, from sand to clay. Begin seedbed preparation early, but only when the soil has dried sufficiently to form a ball that crumbles into medium-size fragments with finger pressure. Kohlrabi quality will be enhanced by working in large amounts of organic matter.

Planting

Kohlrabi can be seeded directly into the soil or transplanted. To grow transplants, sow kohlrabi seeds into containers 6 weeks before the desired transplant date.

Planting specifications:

- Seed spacing: 1–1.5 inches
- Final spacing: 12–18 inches*
- Ounces of seed per foot: 0.01
- Row width: 18–24 inches
- Seed depth: 0.5 inch
- Germination: 3–10 days

**Transplant spacing is the same as for final spacing of direct-seeded kohlrabi.*

Fertilizer

Kohlrabi requires only moderate amounts of fertilizer due to its short production period. Fertilizer can be applied during soil preparation. A 10-10-10 or similar fertilizer formulation is appropriate. Add the equivalent of 0.25 to 0.35 lb N (in combination with P and K) per 100 square feet.

Weed control

Season-long control of weeds in kohlrabi is essential for maximizing production and quality. Kohlrabi does not compete well with weeds. Hand pulling, cultivation, or use of a labeled garden herbicide will control or eliminate most annual weeds.

Irrigation

Once established, kohlrabi will do fine with any irrigation regime that maintains reasonable soil moisture. For most soils, apply 1 to 1.5 inches of water every 3 to 5 days. If the soil is allowed to dry out, kohlrabi will develop a strong flavor and woody texture.

Insects

Common pests of kohlrabi in Idaho include aphids and cutworms. Aphids can be washed from the plant using a hard stream of water. Serious infestations may require the use of a labeled insecticide. Cutworms often kill seedlings or new transplants by chewing them off at ground level. Placing small cardboard collars around the base of the plants often prevents this problem.

Diseases

Diseases of kohlrabi in Idaho gardens seldom require control measures.

Harvest

Kohlrabi should be ready to harvest 50 to 60 days after transplanting. It has the best flavor when it is 2 to 4 inches in size and the flesh is still tender. The leaves of the young plant may be used like spinach.

Storage

If kept refrigerated at near-freezing temperatures and high humidity, kohlrabi can be stored for several weeks.

Consumptive yield

Compute household planting requirements as follows:

- 2–4 lb fresh kohlrabi per person
- 4–8 lb canned or frozen kohlrabi per person
- Each foot of row will yield 0.75 lb.

Plant 3–16 feet of row per person.

Nutritive value

A large serving of kohlrabi will supply your daily requirement for vitamin C. Kohlrabi is also a good source of vitamin B6, iron, phosphorus, potassium, and manganese. One hundred grams (3.5 oz) of kohlrabi contain 1.7 grams of protein, 0.1 gram of fat, 6.2 grams of carbohydrates, 27 calories, and 3.6 grams of dietary fiber. Fresh kohlrabi is 91 percent water.

LETTUCE



Lettuce (*Lactuca sativa*) is by far the most popular salad plant. Various types of lettuce have been cultivated in many parts of the world since ancient times. Modern cultivars were very likely derived from wild lettuce. Wild lettuce now grows throughout the world, but it probably originated in Asia Minor, Iran, and Turkistan.

Herodotus described lettuce being served on the tables of Persian kings as far back as 600 B.C. One to two hundred years later, Greek writers described the virtues of lettuce. Roman gardeners were growing and improving this popular vegetable by the beginning of the Christian era. Their writings show that they had developed at least a dozen cultivars.

Most of the original cultivars of lettuce were leafy types. Head-forming types were developed much later, but seem to have been well developed in Europe by the 16th century. Romaine lettuce was first described in the early 1600s. This type was fairly common in Italy and a few other areas of Europe. Columbus brought lettuce to the New World in 1494. After that, it was slowly introduced to many parts of North and South America.

Lettuce is sensitive to high temperatures. Summer heat will cause most types to bolt (go to seed) and develop bitter flavor. Hot Idaho summers make it especially difficult to produce quality head lettuce. Selection of heat-resistant cultivars is critical to success. Leaf, butterhead, Romaine, and some Batavia lettuce cultivars are less affected by heat, although bolting still occurs more quickly in warm weather.

Growing suggestions

Lettuce can grow well with some shade. When the weather is especially warm, lettuce quality is actually better if plants are shaded in the afternoon or grown under a shade cloth.

Soil type and soil preparation

Lettuce will grow in almost any type of soil. For production of the best quality leaves, the soil must be fertile and have adequate organic matter. Lettuce is usually planted very early in the spring. Consequently, it is important to make sure the soil is not too wet when tilling. The soil should be damp but not wet.

Planting

Lettuce seeds are typically planted directly in the garden, but they may be sown indoors or in cold frames for transplanting. Lettuce is quite cold-tolerant and can be planted early in the spring (3 to 4 weeks before the average last killing frost) or as soon as soils are dry enough to be worked.

Succession planting can create a constant supply of lettuce throughout the summer. Plant additional seeds when plants of the previous crop reach about 1 inch in height. Plant beginning in early spring and ending a few weeks before average first frost.

Planting specifications:

- Seed spacing: 1.5–3 inches
- Final spacing (leaf): 6–8 inches
- Final spacing (head): 6–12 inches
- Row width: 18–24 inches
- Seed depth: 0.25–0.5 inch
- Germination: 4–8 days

Fertilizer

Lettuce has a very high demand for N, but has a short production cycle. Consequently, a single application of fertilizer at planting time is usually adequate. A 10-10-10 fertilizer formulation (or product with similar ratios) is usually suitable. Apply the equivalent of 0.3 lb N (in combination with P and K) per 100 square feet during soil preparation. If using succession planting, apply fertilizer at the time of each new planting. Alternatively, if the seedbed was fertilized with the rest of the garden in the spring, add an additional small amount of N with each planting.

If soil tests indicate adequate levels of P and K, consider using a high-N fertilizer such as 21-0-0 or 46-0-0. Adjust the application rate to account for the percentage of N in the product.

Weed control

Season-long weed control is essential for lettuce. Hand-pulling, cultivation, or application of a labeled garden herbicide are effective control options. Cultivation should be shallow because lettuce has a shallow and limited root system. Deep cultivation close to the plants will destroy much of the root system and can reduce yield and quality.

Irrigation

Because of the shallow root system, lettuce should be watered frequently in order to support rapid leaf development. Inadequate water supply will lead to poor growth and bitter flavor. On most soil types, apply 1.25 to 1.5 inches of water every 4 or 5 days. On sandy soils, apply smaller amounts, but more frequently.

If possible, avoid overhead sprinkler irrigation on lettuce. Wetting the leaves often causes leaf scorch and encourages leaf diseases. These problems reduce quality and shorten the productive life of the plants.

Insects

Insect problems on lettuce rarely require control measures. However, many insects do feed on lettuce, including aphids, leafminers, flea beetles, loopers, cucumber beetles, cutworms, army worms, and slugs. If infestations are severe, several organic or traditional control measures are effective.

Diseases

The short productive life span of lettuce generally precludes serious disease problems. In Idaho, white mold and stem rots may be problematic. To prevent these diseases, avoid over-watering and, if possible, avoid using overhead sprinklers.

Harvest

Leaves of plants pulled during thinning can be used for early salads. Harvest of leaf lettuce can begin as soon as leaves are large enough to eat. Leaf lettuce can be harvested multiple times, so it is important to avoid damage to the crown and new leaves when harvesting older leaves.

Head lettuce is ready to harvest when the heads are solid and of adequate size. Butterhead lettuce can be harvested as soon as the heads form. Head lettuce and butterhead lettuce are usually harvested only once.

Storage

Lettuce is not usually stored. However, if kept refrigerated in a plastic bag, it can be held for several days.

Consumptive yield

Compute household planting requirements as follows:

- 4–5 lb fresh lettuce per person
- Each foot of row will yield 0.5 lb.

Plant 8–10 feet of row per person.

Nutritive value

Lettuce is not considered a nutrient-rich food; however, it does contain significant amounts of several vitamins and minerals. It is an excellent source of vitamin K and vitamin A. It is also a good source of vitamin C, thiamin, riboflavin, folate, vitamin B6, iron, and manganese. One hundred grams (3.5 oz) of fresh leaf lettuce contain 15 calories, 1.4 grams of protein, 0.2 gram of fat, and 2.9 grams of carbohydrates. Fresh lettuce is 95 percent water.

ONIONS



Onions (*Allium cepa*) were grown in Chinese gardens as early as 5000 B.C. In Egypt, the use of onions can be traced back to about 3500 B.C. Studies show that the Sumerians were growing onions as long ago as 2500 B.C.

Ancient Egyptians worshipped the onion. They believed that its round shape and concentric rings represented eternal life. In Egyptian burials, onion slices were placed over the eye sockets. It was believed the strong scent of onions would bring the dead back to life.

Roman gladiators often received onion massages in the belief that the onion juice would firm up their muscles. During the Middle Ages, onions were often used for barter or given as gifts. Doctors prescribed onions to improve bowel function and to provide relief for headaches, hair loss, and even snake bites.

In 1492, Christopher Columbus introduced onions to the New World. They have since become one of the most popular vegetables around the world.

The length of summer days provides a trigger for onions to grow bulbs. There are onions that bulb best where summer days are short (low latitudes), moderate (medium latitudes), or long (high latitudes). It is very important to choose moderate- to long-day cultivars for Idaho's medium to high latitude.

Growing suggestions

Planting onion sets (small bulbs) is a very convenient and dependable way to grow onions in the garden. However, not all onion cultivars respond well to the process of set production, namely partial growth, harvest, and storage at the immature stage. Onions available for planting as sets are usually the pungent, flattish Spanish onions. The large, round, mild "Walla Walla" type onions are not available as sets and therefore must be planted using seeds or transplants.

Soil type and soil preparation

Onions grow well in a wide range of soils and climates, but they develop best in a loose, crumbly soil with high fertility. They can be planted very early, as soon as the soil is dry enough to till. Begin seedbed preparation when the soil has sufficient moisture to form a ball that will crumble with finger pressure into medium-size fragments. Onions benefit from consistent addition of organic matter, regardless of soil type.

Planting

Onion seed may be sown indoors for transplanting later or direct seeded into the garden, or onions may be planted from sets. In short-season areas of Idaho, it is best to utilize transplants or sets.

When growing onion transplants indoors, sow the seeds about 8 weeks before the average last killing frost date. Seeds are small, so plant them only about 0.25 inch deep and about 0.5 inch apart in a tray. If the plants get tall enough that they begin to tip over, trim them with a pair of scissors to about 3 inches tall. Trimming can be done more than once. Onion seedlings are not as frost-tolerant as are sets. Place them in the garden about a week after the average last frost date. They will transplant better if hardened off.

Onions that are direct seeded into the garden do not go through the shock of being uprooted and replanted. This method minimizes stress and disease potential and results in plants that are less likely to bolt. It also produces onions that will store better.

If using onion sets, sort them into two sizes: sets smaller than 0.75 inch and those that are larger. Use the larger sets for green onions because they frequently form seed stalks instead of a bulb. Plant these sets 1 to 2 inches apart.

Planting specifications:

- Seed spacing: 0.75–1.25 inches
- Final spacing: 3–4 inches
- Ounces of seed per foot: 0.2
- Row width: 12–14 inches
- Seed depth: 0.5 inch
- Sets depth: 2–3 inches
- Germination: 7–12 days

Fertilizer

Onions are considered to be high users of nutrients, due more to their shallow root system than to their actual nutrient needs. Onions use nutrients over a long period, so apply fertilizer two times. The first application can be made during soil preparation. The second is typically made no later than mid-July. If fertilizer is added later, the plant may revert to leaf growth at the expense of bulb growth.

Onions do best with a balanced fertilizer program and benefit from fairly high levels of P. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet before planting. A 10-10-10 fertilizer formulation (or product with similar ratios) is usually suitable. Sidedress an additional 0.25 lb N by mid-July. For sidedressing, it is appropriate to use a high-N product such as 21-0-0 or 46-0-0.

Weed control

Direct-seeded onions emerge more slowly than most weed competitors. It is important to avoid damaging or killing emerging seedlings during early weed-control activities. Carefully mark the planting location, in case weeding is needed before crop emergence. Hand weeding is best for removing early weeds.

Onions provide little or no competition for weeds and require season-long, intensive weed control. Weeds can be controlled by hand-pulling, cultivation, or use of a labeled garden herbicide. Onions have very weak, shallow roots, so cultivation should be shallow.

Irrigation

Their shallow root system and relatively high demand for water mean that onions should be watered fairly lightly and frequently. On most soil types, apply 1 to 1.5 inches of water every 3 or 4 days. On sandy soils, irrigation may be required even more frequently. Frequent watering becomes less critical toward the end of the season.

Insects

Many insects can cause severe damage to onions, including onion thrips, onion maggots, pea leafminers, and wireworms. A severe outbreak of onion thrips may require the use of a labeled insecticide. Onion maggots and wireworms can destroy the bulbs, and control can be difficult. Crop rotation may help, especially in preventing maggot damage. Application of a granular insecticide at planting can be helpful if the site has a history of problems with these pests.

Diseases

In Idaho, onions are potentially subject to a number of serious diseases. Plate rot, pink rot, and neck rot are soil-borne fungal diseases that infect onions while growing in the garden. If unlucky enough to have one of these diseases in the garden, there is very little a gardener can do, other than employ crop rotation. These diseases infect the bulbs during growth, but often do not create serious problems until onions are in storage. Inspect onions at harvest. If there is any sign of disease on the root surface or neck tissue of the bulbs, use these onions immediately rather than trying to store them. Foliar diseases, such as powdery mildew and downy mildew, although sometimes visible, usually do minimal damage to onions.

Harvest

Green onions can be harvested at any stage of growth, either before or after bulbing is initiated. Simply pull the onions from the ground by hand to avoid disturbing nearby plants.

Proper harvest of mature onions is more complex. Softening of the neck tissues allows the leaves to fall over (known as top break), indicating maturity. Once half or more of the onions break, the crop is ready to pull and cure. Curing is essential if onions are to be stored. Cure onions by leaving them on the soil surface or other dry place until tops and outer scales are completely dry. Drying can take up to a week. Do not allow the onions to be rained on during curing. After the bulbs are cured, remove the dried tops.

Storage

The pungent Spanish-type onions generally store better than the large sweet onions. Onions store best refrigerated at near 32°F. However, they are damaged by temperatures below 30°F, so it is important to carefully control storage conditions. Onions do best with only moderate levels of humidity in storage. Cold, relatively dry conditions are often difficult to find in home storage facilities, but a dry cellar or attic may suffice. Under proper conditions, onions can be stored for 6 months or longer.

Consumptive yield

Compute household planting requirements as follows:

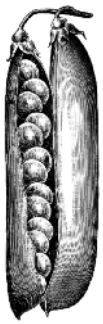
- 3–5 lb fresh onions per person
- 15–20 lb dried or stored onions per person
- Each foot of row will yield 0.75 lb.

Plant 4–33 feet of row per person.

Nutritive value

Due to the presence of the compound allacin and the trace mineral chromium, onions help moderate the symptoms of diabetes. They are an excellent source of vitamin A and a good source of vitamin B6, vitamin C, and manganese. One hundred grams (3.5 oz) of fresh chopped onions contain about 40 calories, 0.1 gram of fat, 9.3 grams of carbohydrates, 1.1 grams of protein, and 1.7 grams of dietary fiber. Fresh onions are 89 percent water.

PEAS



Field peas were among the first crops cultivated by humans. Archaeologists and historians think the garden pea (*Pisum sativum*) may have originated in China or Egypt. Peas found in what is called "Spirit Cave," located between Myanmar (Burma) and Thailand, have been carbon dated to 9750 B.C. These peas were probably growing wild and were gathered rather than cultivated. Peas have also been found in archaeological digs in northwestern Iraq that date back as far as 7000 B.C. In Switzerland, peas were found that date to about 3000 B.C.

Peas were not widely eaten in early history. The Romans seemed to prefer the taste of chickpeas over that of garden peas. During the Middle Ages, peas were sometimes dried and kept for use in times of famine.

When explorers prepared to sail to the American continent, they took along dried peas. Peas were easy to store and kept for long periods of time. A list published in 1635 showing supplies needed for one colonist for 1 year listed "one bushell of pease." Europeans didn't start eating fresh peas until the late 17th century.

Peas are classified as smooth or wrinkled according to how the seed looks when dry. The wrinkled seed types are normally the sweetest.

Growing suggestions

Obtaining a good stand of peas can be one of the most challenging problems associated with growing this crop. Peas are very susceptible to a number of rot organisms that kill the seedlings before or just after emergence. See "Diseases" for managing this problem.

Early planting is essential because peas do not set pods in extreme summer heat. It is important that the crop be ready to harvest by the time it gets hot. Luckily, peas are cold-tolerant and can be planted up to 5 weeks before average last spring frost.

Soil type and soil preparation

Peas will grow in any well-drained garden soil. They do best in soils that do not crust. They require only routine soil preparation.

Planting

Plant peas as soon as the ground can be worked in the spring, usually 3 to 5 weeks before average last spring frost. Maximum daytime soil temperature at the time of planting should approach 50°F.

Peas can be planted in a variety of row designs. Some gardeners plant peas in a block with seeds planted on a grid about 2 inches apart in each direction. Peas planted in this way will support one another without the use of a trellis. Others plant a double row of peas about 6 inches apart, with the seeds placed 2 inches apart in the rows. When planting single or double rows, it may be desirable to install a trellis for the peas to climb.

Planting specifications (single row):

- Seed spacing: 1.5–1.75 inches
- Final spacing: 3–4 inches
- Ounces of seed per foot: 0.16
- Row width: 18–30 inches
- Seed depth: 1.5–2 inches
- Germination: 6–15 days

Fertilizer

Take care when fertilizing peas. Peas are a legume and are able to produce much of their own N. Excess N can cause the plants to produce large vines, but fewer peas. Although peas require minimal applications of N, levels of P, K, and other

nutrients must be adequate to ensure productivity. Apply fertilizer during soil preparation. A 5-10-10 or similar fertilizer formulation that is low in N and high in other nutrients is best for peas. The equivalent of 0.1 to 0.2 lb N (in combination with P and K) per 100 square feet will provide adequate nutrients.

Weed control

Season-long weed control is important for peas because they are only moderately competitive with weeds. Achieve control through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Be careful when cultivating close to pea plants to avoid damaging the root systems.

Irrigation

Peas have a shallow root system and little tolerance of drought stress. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1 to 1.5 inches of water every 3 to 5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Many insects feed on peas, but few become problematic. Pea aphids may occasionally reach population levels that require control. Washing them off the plants with a hard stream of water usually provides adequate control. In some parts of Idaho, pea weevils are problematic. Larvae penetrate the pods and feed on the developing seeds. A timely insecticide application to control the adults before egg laying may be required.

Diseases

Seed and root rots impact emergence of peas. These problems are managed by planting in warm soil (above 50°F), planting after soil dries partially, and delaying irrigation until after emergence. White mold occasionally damages pods that touch the ground. Staking the vines and allowing the soil surface to dry between irrigations usually eliminates this problem. Peas are also susceptible to a number of viruses. These diseases are usually kept in check by buying certified seed from a reputable source.

Harvest

Pick peas during the cool part of the day so they remain crisp. Harvest garden peas when pods are nearly full, but before pods begin to wrinkle. If allowed to mature too long, peas become starchy and lose their sweetness. Peas also become starchy if left to sit at room temperature after harvest. As little as 4 hours is enough time to significantly reduce quality.

Harvest edible pod peas while the pods are still flat and the peas are hardly discernible. Pick these peas every other day to prevent over-maturity.

Storage

In order to maximize quality, do not store peas. They should be consumed, frozen, or canned immediately. If immediate use is not possible, peas can be stored in the pod for a few days at high humidity and a temperature near 32°F.

Consumptive yield

Compute household planting requirements as follows:

- 4 lb fresh peas per person
- 10 lb canned or frozen peas per person
- Each foot of row will yield 0.3 lb.

Plant 13–46 feet of row per person.

Nutritive value

Peas contain significant quantities of many nutrients, including some that are difficult to obtain from other vegetables. They are an excellent source of niacin, vitamin C, and potassium. They are also a good source of vitamin K, riboflavin, thiamin, vitamin B6, folate, iron, phosphorus, magnesium, manganese, and zinc. One hundred grams (3.5 oz) of peas contain 81 calories, 0.4 gram of fat, 14.5 grams of carbohydrates, 5.4 grams of protein, and 5.1 grams of dietary fiber. Fresh peas are 79 percent water.

PEPPERS



Peppers (*Capsicum annuum*) belong to the Solanaceae family, as do tomatoes and potatoes. Christopher Columbus found these plants growing in the New World and brought them back to Europe. He named them peppers because he mistakenly believed they were related to the plants that yielded the highly prized peppercorn.

Peppers are native to Mexico, Central America, and northern South America. Historians believe that

chili peppers were probably the first plants to be domesticated in Central America. Evidence suggests they were consumed as early as 7500 B.C. It is believed that other groups of people in North and South America developed domesticated varieties for cultivation. After Columbus brought peppers back to Spain, they slowly spread to other European and Asian countries. The impact of bringing the pepper plant to other parts of the world has been phenomenal. It has become one of the most important and widespread vegetable crops worldwide.

Extremely hot and pungent cultivars are often grown in South Asia. These types were introduced into these areas by Portuguese and Spanish explorers, probably in the 16th century.

Most peppers are categorized as either sweet or hot, depending on how much pungent capsaicin they contain. They range from very mild and sweet to so hot they are almost inedible. A rating system called the Scoville scale has been developed for quantifying the "heat" in various peppers. For example, bell peppers are rated at 0 Scoville units because they have no detectable "hotness." Jalapeño peppers rate between 2,500 and 6,000 Scoville units. Cayenne peppers rate between 30,000 and 50,000 Scoville units, and Habañero peppers rate between 100,000 and 500,000 Scoville units. The hottest pepper on record, derived from the ghost peppers of India, was measured at 2.3 million Scoville units.

Growing suggestions

Peppers grow best in very warm climates. In short-season areas of Idaho, production is enhanced by planting on the south side of a structure, planting on black plastic, or using row covers.

Soil type and soil preparation

Peppers can be grown in most types of soil, as long as the soil is well drained. Pepper fruits will mature more quickly when grown on lighter soils. Peppers grow best when supplied with sufficient organic matter. Soils low in organic matter should be amended with compost or manure (added the previous fall, if possible). Work soil well to produce a deep, friable bed. Good soil tilth helps pepper plants develop a healthy root system.

Planting

In Idaho, peppers are almost always grown from transplants, partially because of the need to speed maturity and secondarily to overcome germination problems. Purchase healthy transplants or grow your own by sowing pepper seeds indoors or in the greenhouse 6 to 8 weeks before the intended transplant date. Transplants should be stocky and from 4 to 6 inches tall. Newly transplanted pepper plants require protection from frost, wind, and intense sun.

Transplanting specifications:

- Final spacing: 15–18 inches
- Row width: 24–36 inches

Fertilizer

Peppers do best with a balanced fertilizer program and respond to adequate levels of P and K. They have a fairly high demand for nutrients over a long growing season. Add fertilizer in two separate applications. Apply 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or product with similar ratios) is usually appropriate. Sidedress an additional 0.3 lb N when the plants begin flowering and setting fruit. The product selected for sidedressing should be high in N, e.g., 21-0-0 or 46-0-0.

Weed control

Season-long weed control is important for pepper production. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Once rapid growth begins, tillage activities close to plants should be shallow in order to prevent root damage.

Irrigation

Peppers require moderate amounts of water on a consistent schedule. If allowed to wilt, production will decline and fruit will lose quality. Irrigate peppers with 1.5 to 2 inches of water every 5 to 7 days.

Insects

Other than spider mites, there are no major insect pests of peppers in Idaho gardens. Mites can be controlled by using overhead irrigation or occasionally wetting the leaves.

Diseases

Virus diseases are common in peppers. Plants that become unthrifty and have malformed and mosaic color patterns in the leaves are likely infected. Remove these plants to prevent them from competing with healthy plants. Verticillium wilt, a soil disease that causes plants to wilt, become yellow, and lose leaves is also common in many places in Idaho. This disease is partially controlled through crop rotation.

Harvest

Peppers can be harvested at any time after they are large enough to use. Bell types usually are harvested when they are 3 to 4 inches long. Hot peppers grown for salsas and sauces can be picked when they reach the desired size and color. When picking peppers, cut them from the plant rather than pulling them. If the end cap is pulled off, the fruit will quickly rot.

It is important to harvest peppers on a consistent schedule. Allowing fruit to hang on the plant until completely mature will delay the setting of additional fruit. Hot peppers grown for drying are the exception. Leave them on the plant until they are wrinkled and partially dry. After harvest, place them in a sunny, hot place to complete the drying process.

Storage

Peppers can develop cold injury symptoms in a refrigerator. They are best stored in an unheated basement or storage room at 45° to 50°F. If conditions are good, they may keep for up to 2 weeks, although they will probably lose moisture and become wrinkled. An alternative is to slice and/or dice peppers and then dry them in an oven or dehydrator. They can then be stored in a glass jar. When dried properly, these peppers should remain flavorful for about 1 year.

Consumptive yield

The amount of peppers required to supply household needs varies widely, due to differences in types of pepper, intended use, and processing methods. Experience will dictate how many to plant.

Nutritive value

Peppers are used mostly as a seasoning rather than a staple food. However, sweet peppers are often eaten in quantity and become important nutritionally. They are a good source of B-complex vitamins. Peppers are one of the best sources of vitamin C among vegetable crops. They are also a good source of vitamin K and manganese. One hundred grams (3.5 oz) of raw sweet, green peppers contain 20 calories, 0.2 gram of fat, 0.9 gram of protein, 4.6 grams of carbohydrates, and 1.7 grams of dietary fiber. Peppers contain 94 percent water.

POTATOES



Potatoes (*Solanum tuberosum*) were critical to the development of the Andean cultures in South America. For thousands of years, they have provided a consistent, nutritious food source for these mountain-dwelling peoples. Potatoes were of such importance that they became deeply ingrained into every facet of society, including religion.

Andean potato varieties, still critical to food supplies in much of South America, are quite different from those grown in the United States and Europe. Tubers are typically small and come in a variety of colors and shapes. Occasionally, these native varieties are available for planting in gardens, and it can be enjoyable to grow, prepare, and eat these interesting potatoes.

There are many cultivars of potatoes available. The type of potato often dictates product quality. Red potatoes are often harvested early and are good for boiling and making hash browns. White potatoes are good boiled and sometimes make great potato chips. Russet potatoes are usually great for baking or making French fries. In Idaho, many people prefer Russet Burbank potatoes. This cultivar is often difficult to grow in the garden. It must be consistently supplied with large amounts of water and fertilizer to perform well. If these conditions cannot be provided, choose another cultivar.

Growing suggestions

The single most important tip for growing potatoes is to always buy new, certified seed potatoes. Potatoes are propagated by planting the current crop using tubers from last year's crop. This practice means that any diseases present in the last

crop will be transferred to the new crop. Using certified seed potatoes ensures that such diseases are minimized. Never plant potatoes sold in the grocery store for food. These potatoes are often treated with antisprouting compounds that prevent normal growth.

Soil type and soil preparation

The largest, smoothest potatoes are produced in loamy or sandy soils. Clay soils often result in malformed tubers. Heavy soils can be improved with the application of large amounts of compost or manure.

Potatoes need soil that is loose and deeply tilled. Tubers will not develop properly in packed or hard soil. Till soil to a depth of at least 10 inches. Avoid tilling soil that is too wet.

Planting

Be sure to purchase and plant certified seed potatoes. Cut seed potatoes into pieces that weigh 2 to 3 ounces (about 2 inches long and 1 to 1.5 inches wide).

Potatoes can be planted about 2 weeks prior to average last spring frost, or even slightly earlier if you don't mind a little frost damage to the newly emerged sprouts. Early planting is important if you want an early harvest of new, summer potatoes. Soil temperature is important for healthy sprout development and should be approaching 50°F at the time of planting. As the plants start to emerge, mound a few inches of loose soil around them to ensure that the developing tubers remain covered with soil.

Planting specifications:

- Seed piece spacing: 1 foot
- Final spacing: 1 foot
- Ounces of seed tubers per foot: 2–3
- Row width: 30–36 inches
- Seed depth: 5 inches
- Emergence: 18–25 days

Fertilizer

Potatoes are considered to be heavy users of nutrients. In reality, they can grow with limited fertility, but they produce the largest tubers and highest yield with adequate nutrition. Potatoes respond positively to adequate levels of N, P, and K. Potatoes do best with split applications of fertilizer. Add the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation is usually adequate. Sidedress an additional 0.25 lb N when the plants are about 12 inches tall. It is appropriate to use a product containing P and K for sidedressing.

Weed control

Early-season weed control is important for potatoes. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Hilling soil around the plants is helpful. Once mature, plants compete well with weeds.

Irrigation

Consistent irrigation is important for producing smooth, high-quality potato tubers. To keep the seed pieces healthy, delay irrigation until after the sprouts emerge, if possible. Once emerged, plants require relatively frequent, small applications of water. On clay or loam soils, apply 1 to 1.5 inches of water every 3 to 5 days. On sandy soils, apply smaller amounts, but more frequently. As plants mature, irrigation can be less frequent.

Insects

Colorado potato beetles are the most damaging insect pest of potatoes. The bright orange larvae of this insect can completely defoliate plants within a few days. In a small garden, the larvae can be removed by hand and destroyed. With large numbers of plants, control may require the use of an approved standard or organic insecticide.

Diseases

Potatoes are prone to a number of very serious diseases. A variety of viral diseases can appear at any time during the growing season. Removal of infected plants is the only defense against further spread. Plants showing leaf mottling or serious malformation should be removed and destroyed.

A soil fungal disease called verticillium wilt causes plants to become weak, turn yellow, and develop burned leaf edges. This disease is very common in southern Idaho. Other than planting resistant cultivars, the only ways to manage this disease are to avoid planting in infected soil and to pull and destroy infected plants. Crop rotation will help minimize symptoms.

Both early and late blight cause leaf spotting and leaf drop on potatoes. Under the right conditions

(cool, cloudy, rainy), these diseases can rapidly kill plants and may rot the tubers. These diseases can be controlled with multiple applications of a labeled garden fungicide, beginning immediately after symptoms are detected.

Harvest

Tuber harvest can begin as soon as potatoes are large enough to eat. Immature tubers tend to lose their skin during handling and should be consumed shortly after harvest. If potatoes are intended for storage, let them grow into the cool weather of fall. Then kill or remove the vines and leave the tubers in the ground to mature for about 3 weeks. Finally, harvest tubers carefully to avoid damage.

Storage

Potatoes can be stored for 6 months or longer if provided with the right conditions. They need temperatures of 40 to 45°F and humidity over 95 percent. Supplying these conditions may require a root cellar or a refrigerator dedicated to produce storage. Potatoes must be kept in the dark to prevent greening and bitterness.

There is a direct relationship between storage temperature and frying quality of potatoes. If potatoes are to be used for making chips or fries, they must be stored at a warmer temperature than if they are to be baked or boiled. When fried, potatoes stored at temperatures below 45°F turn brown and taste burned.

Consumptive yield

Compute household planting requirements as follows:

- 60 lb fresh and stored potatoes per person
- Each foot of row will yield 2 lb.

Plant 30 feet of row per person. (If no storage is planned, 5 feet of row per person is adequate.)

Nutritive value

Potatoes are one of the few vegetables to be considered a complete food. They provide most of the essential nutrients needed by humans, including a high-quality protein. Potato tubers are also a good source of vitamin B6 and contain valuable amounts of vitamin C, thiamin, niacin, potassium, phosphorus, iron, magnesium, and manganese. Potatoes with yellow flesh also provide vitamin A. One hundred grams (3.5 oz) of fresh potatoes contain 2.1 grams of protein, 0.1 gram of fat, 18 grams of carbohydrates, 79 calories, and 1.3 grams of dietary fiber. Fresh potatoes consist of 79 percent water.

PUMPKINS AND WINTER SQUASH



Pumpkins and winter squash (*Cucurbita* spp.) are botanically identical and are grown in a similar manner. Pumpkins are used primarily for decorations, although pumpkin pie is the final fate of many pumpkins. Winter squash are used primarily for food, including pie.

Pumpkins and winter squash are believed to have originated in the region between northern South America and the southwestern United States. Seeds from closely related plants dating back to 7000 to 5500 B.C. have been found in Mexico. Native Americans used pumpkins and squash as a dietary staple several centuries before the Pilgrims landed.

Very early explorers took pumpkins back to Europe. The Greeks named the fruits “pepon,” which meant “large melon.” The French changed the pronunciation to “pompon.” The English later changed “pompon” to “pumpion,” and Shakespeare mentioned the “pumpion” in his “Merry Wives of Windsor.” American colonists changed the name from “pumpion” to “pumpkin.”

Winter squash and pumpkin cultivars are derived from three separate cucurbit species. The three species do not freely intercross. However, all three produce fruits that are consumed in their mature phase or used for fall decorations. Winter squash cultivars come in an amazing array of sizes, shapes, and colors. Pumpkins and most winter squash fruits have yellow or orange flesh, although a few have white flesh. Most winter squash and pumpkin cultivars are vining or semivining and grow to be very large, sprawling plants.

Growing suggestions

Pumpkins and winter squash grow best in a warm site with full sun. Warm soil is essential to good seed germination and emergence. Using transplants can speed production.

Soil type and soil preparation

Pumpkins and winter squash will grow in almost any well-drained soil, but prefer sandy or loamy soils. They are most productive on fertile soils with adequate levels of organic matter. Prior to planting, amend soils to enhance fertility, organic matter content, and drainage. Till soil as deeply as feasible to create a deep, mellow seedbed. Mounding or hilling the soil can improve drainage and increase soil temperatures.

Installing black plastic mulch prior to planting can warm the microclimate around plants, speeding harvest and improving productivity. Plastic mulches also help control weeds, thereby reducing the need for herbicides and cultivation.

Planting

Pumpkin and squash seedlings are extremely susceptible to frost. They should not be direct seeded in the garden until about 1 to 2 weeks after average last frost. Daytime soil temperatures at planting time should consistently be above 65°F.

Transplant pumpkin and squash plants to the garden 2 to 3 weeks after average last frost. Transplants should be small (one or two true leaves), dark green, and growing vigorously. Protect them during the first week from wind, direct sun, and cold.

Planting specifications:

- Seeds per hill: 3–5
- Distance between hills: 5–6 feet*
- Final stand per hill: 2–3
- Ounces of seed per foot: 0.05
- Row width: 6–10 feet
- Seed depth: 1 inch
- Germination: 5–14 days

**Hill spacing for transplants is the same as for seed.*

Fertilizer

Pumpkins and winter squash need fairly high levels of N, P, and K and do best with a balanced fertilizer program. They are fairly high users of nutrients over a long period of the season, so apply fertilizer twice. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or product with similar ratios) is usually adequate. Sidedress an additional 0.25 lb N before flowering. Nitrogen is the most important nutrient for the sidedress fertilizer application, so a product made up primarily of N (e.g., 21-0-0 or 46-0-0) will work fine.

Weed control

Early-season weed control is important for pumpkin and squash production. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Tillage activities close to plants should be shallow in order to prevent damage to feeder roots. Weed control becomes less essential later in the season.

Irrigation

Due to their requirement for warm temperatures at planting time, pumpkin and squash seeds may need one or two light irrigations to ensure good seedling emergence. Once established, these crops do best with infrequent, deep irrigation. On clay or loam soils, apply 1.5 to 2 inches of water every 5 or 6 days. On sandy soils, apply smaller amounts, but more frequently. If plants are allowed to wilt, fruit shape and eating quality will be negatively affected.

Insects

Several species of aphids and squash bugs can become problematic on pumpkins and winter squash. Control aphids by using an insecticidal soap, spraying the affected parts of the plants with a hard stream of water, or applying a registered insecticide. Pick squash bugs from the plants and destroy them, or use an insecticide. Wireworms can damage roots, stems, or the fruit where it touches the ground. They are very difficult to control during the growing season. If problems with wireworms persist over several seasons, a preventive spring application of a soil insecticide may be necessary.

Diseases

Pumpkins and squash can be infected by a number of root rot diseases, viruses, and fungal leaf diseases. In Idaho, disease problems are generally minimal due to low humidity and short seasons. However, viruses and root rots occasionally reach levels that require control.

Virus symptoms include malformed or splotchy leaves or fruit. These diseases cannot be cured. They are usually controlled through removal and destruction of infected plants.

Root rots are nearly impossible to treat once symptoms appear. The best prevention is to avoid over-watering (or overly frequent watering). Also, avoid planting squash plants in low spots where water may accumulate.

Powdery mildew is a disease that often appears on winter squash and pumpkins, but is seldom an issue of concern. Symptoms include a white, powdery fungal growth on the upper leaf surface. No control is necessary if symptoms appear during the last month of the season. If symptoms appear earlier, it may be necessary to apply a labeled garden fungicide.

Harvest

Pick pumpkins and winter squash any time after full fruit color is expressed and the rinds are hard. Full maturation does not always occur until after frost kills the foliage. Mild frosts help speed maturation. Moderate to heavy frosts damage the fruit and shorten storage life, even if the fruit heals and returns to a normal appearance. Harvest fruits before they are exposed to temperatures below about 28°F.

Storage

If not completely ripe, store pumpkins and winter squash in a warm (room temperature or above) place for the first few weeks. Once full skin color has developed, they can be moved to long-term storage with temperatures around 50°F and moderate humidity. A cool basement is ideal. Under the right conditions, some types of winter squash will store for several months.

Consumptive yield

Compute household planting requirements for squash as follows:

- 6–9 lb fresh and stored squash per person
- 6–9 lb processed squash per person
- Each foot of row will yield 1 lb.

Plant 6–18 feet of row per person.

Most pumpkin cultivars produce 3 to 6 fruits per hill. If pumpkins are grown for decorative purposes, calculate the number of plants needed based on the number of fruits needed.

Nutritive value

Pumpkins and winter squash vary widely in nutrition. Those with orange flesh are some of the best sources of vitamin A among vegetable crops. Pumpkins and squash also are good sources of vitamin C, vitamin E, vitamin B6, folate, riboflavin, potassium, manganese, and iron. On average, 100 grams (3.5 oz) of fresh pumpkin or winter squash contain 1 gram of protein, 0.1 gram of fat, 8.6 grams of carbohydrates, 34 calories, and 1.5 grams of dietary fiber. Fresh pumpkins and winter squash are 90 to 92 percent water.

RADISHES



Radishes (*Raphanus sativus*) are grown for their colorful, sharp-tasting root and are usually the first spring-planted vegetable to be ready for harvest. They originated in western Asia and are a staple food in China and Japan. Radishes grown commonly in the United States produce roots that are small, spherical, and dark red. However, many types of radishes are available for planting in the home garden. They vary in shape from round to long and in color from red to white (or bicolored). The white Japanese daikon radish is becoming popular in many places.

Growing suggestions

Radishes are best grown in spring or fall when temperatures are moderate. Summer heat results in inferior quality due to increased pungency (heat) and fibrousness (woodiness). Even when grown in optimal temperatures, radish roots remain at their best quality for only a few days. Luckily, it is possible to plant very early in the spring or late in the fall. It is possible to maintain a continuous supply of radishes during spring and early summer (or early to late fall) by succession planting. Plant a new crop of radishes when seedlings from the previous crop are fully emerged. Radishes can also be grown in a container.

Radishes make a great relay crop, meaning they can be harvested early to make way for a warm-season crop in the same location. Some of the crops that can be planted after radishes in Idaho include green beans, cucumbers, melons, pumpkins, and winter squash.

Soil type and soil preparation

Radishes grow well in almost any well-drained soil. They emerge and mature faster in a sandy soil, but often develop the best root color and quality in heavier loam or clay soils. Work the soil to form a smooth, firm seedbed. Work the soil as early as feasible, but avoid working wet soils.

Planting

Radish seedlings are very frost-resistant, so seeds can be planted 3 to 5 weeks before average last frost. Sow seeds directly in the garden. Radishes are small seeded, so they should be planted shallow.

To make the most effective use of space, you can plant radishes in a bed row (a wide row, several plants across) or grouping. Give each radish 1 to 2 square inches of space. To ensure full productive potential, you can over-plant radishes and thin to a final stand after emergence.

Radishes emerge very quickly—within 3 to 6 days depending on daytime temperature. They can produce edible roots in 20 to 30 days, making them one of the earliest vegetables to come from the spring garden.

Planting specifications (single row):

- Seed spacing: 0.5–0.75 inch
- Final spacing: 0.75–1 inch
- Ounces of seed per foot: 0.02
- Row width: 15–18 inches
- Seed depth: 0.5 inch
- Germination: 3–10 days

Fertilizer

Due to their very short production period, radishes require low to moderate levels of N fertilizer. For good root production, they do best with moderate to high levels of P and K. A 5-10-10 or similar fertilizer formulation is usually adequate. A single preplant application of 0.2 lb N (in combination with P and K) per 100 square feet will provide adequate nutrients.

Weed control

Control of early weeds is essential for maximizing production and quality. Hand pulling and cultivation are usually adequate. Late-emerging weeds are not a concern with radishes due to their short production cycle.

Irrigation

Due to their requirement for shallow planting, radishes may need one or two light irrigations after seeding to ensure good seedling emergence. Once emerged, they do best with frequent, light irrigations that maintain soil moisture at a fairly high level. If soil is allowed to dry out, roots become pungent and woody.

Insects

Spring-planted radishes have very few insect pests, in part due to natural resistance, but also because their early-season growth allows them to avoid many problematic pests. Flea beetles sometimes feed on the leaves, creating small, round holes. This damage generally does not affect growth or productivity.

Diseases

Disease control is rarely required for radishes in Idaho gardens.

Harvest

Radishes can be harvested as soon as the roots reach edible size, typically 1 inch in diameter. Larger roots (2 inches or more) often display inferior quality. Once the plants bolt (the blossom stem begins to form), the roots quickly become inedible. Optimal harvest period for quality often lasts for only a few days, depending on temperature.

Storage

Under moist, refrigerated conditions, radish roots can be stored for up to a week. Storage in a perforated plastic bag will help retain quality. Remove the leaves before storage to prevent the roots from losing moisture and becoming rubbery.

Consumptive yield

Compute household planting requirements as follows:

- 2–3 lb fresh radishes per person
- Each foot of row will yield 0.67 lb.

Plant 3–5 feet of row per person.

Nutritive value

Radishes contain flavonoid antioxidants, which help lower the risk of cancers. They are a good source of vitamin C, folate, vitamin B6, and potassium. One hundred grams (3.5 oz) of radishes contain 0.7 gram of protein, 0.1 gram of fat, 3.4 grams of carbohydrates, 16 calories, and

1.6 grams of dietary fiber. Fresh radishes are 95 percent water.

SUMMER SQUASH



All species of squash (*Cucurbita pepo*) and closely related pumpkins and gourds have their origins in the New World, specifically northeastern South America, Mexico, and the southwestern United States. Summer squash are grown for their immature fruits, which come in a variety of sizes, shapes, and colors. Most summer squash fruits have white flesh, although a few cultivars have yellow flesh. Plants of most modern cultivars of summer squash have a compact, bush growth habit. However, some summer squash types are vining or semivining.

Growing suggestions

Summer squash grow best in a warm site with full sun. Warm soil is essential to good seed germination and emergence. Squash can be transplanted to speed production.

Soil type and soil preparation

Summer squash will grow in almost any well-drained soil, but prefer sandy or loamy soils. They produce best on fertile soils with adequate levels of organic matter. Before planting, amend the soil to enhance fertility, organic matter content, and drainage. Till soil as deeply as feasible to create a deep, mellow seedbed. You can improve drainage and increase soil temperatures by mounding or hilling the soil.

Installing black plastic mulch prior to planting can warm the microclimate around squash plants, thereby speeding harvest and improving productivity. Plastic mulches also enhance weed control, reducing the need for herbicides and cultivation.

Planting

It is critical that squash transplants be small (one or two true leaves), dark green, and growing vigorously. Squash seedlings are extremely susceptible to frost. If seeding directly into the garden, delay planting until about 1 or 2 weeks after average last spring frost. Daytime soil temperatures should consistently be above 65°F. If using transplants, protect them during the first week from wind, direct sun, and cold. If protection is not available, do not transplant squash to the garden until at least 2 weeks after average last spring frost.

Planting specifications (bush type):

- Seeds per hill: 3–5
- Distance between hills: 3–4 feet*
- Final stand per hill: 2–3
- Ounces of seed per foot: 0.5
- Row width: 5–6 feet
- Seed depth: 1 inch
- Germination: 5–12 days

**Hill spacing for transplants is the same as for seed. For vining types, space hills 5 to 6 feet apart in rows 8 to 10 feet apart.*

Fertilizer

Summer squash are fairly high users of nutrients and do best with a balanced fertilizer program. They need fairly high levels of N, P, and K. They use nutrients over a long period, so apply fertilizer twice. Apply 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or product with similar ratios) is usually adequate. Sidedress an additional 0.25 lb N before flowering. Nitrogen is the most important nutrient for the sidedress fertilizer application, so a product containing primarily N is adequate (e.g., 21-0-0 or 46-0-0).

Weed control

Early-season weed control is important for squash production. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. Tillage activities close to plants should be shallow in order to prevent damage to feeder roots. Late-season weed control is less essential.

Irrigation

Due to their requirement for warm temperatures at planting time, summer squash seeds may need one or two light irrigations to ensure good seedling emergence. Once established, squash do best with infrequent, deep irrigations. On clay or loam soils, apply 1.5 to 2 inches of water every 5 or 6 days. On sandy soils, apply smaller amounts, but more

frequently. If plants are allowed to wilt, fruit shape and eating quality will be negatively affected.

Insects

Squash bugs and several species of aphids can become problematic on summer squash. Control aphids by using an insecticidal soap, spraying the affected parts of the plants with a hard stream of water, or applying a registered insecticide. Pick squash bugs from the plants and destroy them, or use an insecticide. Wireworms can damage roots, stems, or the fruit where it touches the ground. They are very difficult to control during the growing season. If problems with wireworms persist over several seasons, a preventive spring application of a soil insecticide may be required.

Diseases

Squash can be infected by a number of root rot diseases, viruses, and fungal leaf diseases. In Idaho, disease problems are generally minimal due to low humidity and short seasons. Root rots are nearly impossible to treat once symptoms appear, so prevention is the best strategy. Avoid over-watering (or overly frequent watering) and avoid planting squash in low spots where water may accumulate.

Harvest

Summer squash can be picked at nearly any stage of growth. For best quality, rinds and seed coats should be soft and pliable. In order to maintain plant productivity and maximize fruit quality, harvest squash every day. The presence of large fruit with mature seeds causes the plant to cease setting new fruit.

Storage

Summer squash quality declines very rapidly in storage. Squash generally are not stored or held in refrigeration for more than a day or two.

Consumptive yield

Compute household planting requirements as follows:

- 6–9 lb fresh summer squash per person
- Each foot of row will yield 1.5 lb.

Plant 4–6 feet of row per person. (Additional production may be needed if squash is frozen.)

Nutritive value

Nutrition of summer squash is slightly different than that of winter squash due to differences in cultivars and harvest maturity. Summer squash tend to be a little higher in protein and lower in carbohydrates. They are a good source of vitamin C, riboflavin, vitamin B6, folate, potassium, manganese, and phosphorus. One hundred grams (3.5 oz) of summer squash contain 1.2 grams of protein, 0.2 gram of fat, 3.4 grams of carbohydrates, 16 calories, and 1.1 grams of dietary fiber. Fresh summer squash is 95 percent water.

SWEET CORN



Grain corn has been a staple crop among the native peoples of the New World for more than 5,000 years, especially in and around Mexico. Sweet corn (*Zea mays*), with its use of the crop before the kernels dry, is relatively new. Documented use of sweet corn as an important crop is limited to the past 200 years.

It is important to understand a little about the genetic nature of this crop. Sweet corn kernels express the genetic traits of both the female and male parent. Thus, the source of pollen affects kernel quality. There are three types of sweet corn: standard (su), sugary enhanced (se), and supersweet (sh2). When one type of sweet corn pollinates another, it negates the sweetening gene, resulting in starchy, poor-quality corn. There are two ways to deal with this issue. One is to plant only one cultivar of corn and make sure it is isolated by a few hundred feet from any other corn cultivars. The other is to determine the type of sweet corn being planted and make sure all other cultivars planted close by are of the same type. The class or type is usually indicated on the seed package. If not, it can usually be found by doing an internet search on the cultivar name.

In regions with short-season climates, it is important to plant cultivars that mature quickly. Generally, cultivars that are listed as maturing in 75 days or fewer are suitable.

Growing suggestions

Sweet corn will grow well in almost any type of soil. It requires warm soil and air conditions during much of the growing season to produce a quality

crop. Sweet corn must have full sun for the ears to develop normally.

Sweet corn is wind pollinated, and the pollen must move from the tassel on top of the plant to the silks on the ears. Improper pollination will result in missing kernels. It is best to plant corn in square blocks rather than in long rows. This configuration concentrates the pollen into a smaller area, increasing opportunities for the pollen to reach the ears.

Soil type and soil preparation

Sweet corn does not require special soil preparation. Like most crops, it does better with good fertility, adequate organic matter, and deep tillage.

Planting

Sweet corn seedlings emerge best if soil temperatures are above 60°F, but they will grow, albeit slowly, with soil temperatures as low as 50°F. Seedlings can withstand some light frost when they are still very small. Consequently, sweet corn can be planted as early as a week before average last frost. However, early planting has inherent risks and may not meaningfully influence harvest time.

Once seedlings emerge, thin them to a final stand of one plant every 10 to 12 inches. Closer spacing will cause the ears to be smaller.

Under conditions of warm soil temperatures, sweet corn will emerge in less than a week. In cold soil, emergence may take 2 weeks or more.

Planting specifications:

- Seed spacing: 2–3 inches
- Final spacing: 10–12 inches
- Ounces of seed per foot: 0.16
- Row width: 30–36 inches
- Seed depth: 1.5–2.5 inches
- Germination: 6–14 days

Fertilizer

Sweet corn has a high demand for nutrients over a long growing season, so add fertilizer twice. Sweet corn has a very high demand for N, but also responds to high levels of P and K. Apply the equivalent of 0.3 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or product with similar ratios) is appropriate. Sidedress an additional 0.3 lb N when the plants are 12 inches high. Nitrogen is the most important nutrient for the sidedress fertilizer application, so a product made up primarily of N (21-0-0 or 46-0-0) will work well.

Weed control

Early-season weed control is important for sweet corn production. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. At all stages of growth, tillage activities close to plants should be shallow in order to prevent damage to roots. Once plants are tall, they often suppress weeds through competition and shading.

Irrigation

Sweet corn has a shallow root system. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1 to 1.5 inches of water every 3 to 5 days. On sandy soils, apply smaller amounts, but more frequently. As plants mature, the time between irrigations can be lengthened by a day or two. Sweet corn can withstand some wilting without detrimental effects on the crop.

Insects

Several insects can do significant damage to sweet corn in the garden. Wireworms reside in the soil and often damage the seed before germination. Cutworms, another soil insect, emerge at night and feed on young seedlings. These insects are difficult to control and may require the use of a registered soil insecticide prior to planting. Use of treated seed often helps minimize damage to seed, although not all seed treatments contain an insecticide.

Corn earworms are the other important insect pest of sweet corn in Idaho. Adults lay eggs on green silks. After hatching, larvae eventually make their way into the ear, where they damage kernels near the top end of the cob. Both organically approved and traditional insecticides provide good control of corn earworm if applied multiple times during silking. This insect is less of a problem in short-season climates.

Diseases

Seed rots are the most important diseases of sweet corn in Idaho. They can usually be prevented by planting after the soil warms up and avoiding planting in soil that is too wet.

Corn smut—a gray fungal growth that infects tassels and silks and looks like a puffball mushroom—is often seen in Idaho gardens. It is a systemic disease and will appear on other parts of the plant as well. It can be a serious problem if it infects a large number of ears. Do not leave infected plants as residue, or the problem likely will return. Remove infected plants from the garden as soon as smut is visible. The fungus is edible and is often cooked and consumed as a delicacy in Mexico.

Harvest

Corn is usually ready to harvest when the silks are entirely brown and the husks are tight. Pull back the husk to reveal the top end of the cob and check whether the kernels are the mature color. Once ripe, it is important to pick sweet corn within a day or two to preserve quality.

Storage

Sweet corn quality declines very rapidly in storage. Ears are generally not stored or held in refrigeration for more than 2 or 3 days. For frozen or canned corn, process sweet corn immediately after harvest.

Consumptive yield

Compute household planting requirements as follows:

- 3–5 lb fresh sweet corn per person
- 9–15 lb canned or frozen sweet corn per person
- Each foot of row will yield 0.3 lb.

Plant 10–67 feet of row per person.

Nutritive value

Due to its starchy kernels, sweet corn is higher in calories (86 per 100 grams) and carbohydrates (18.7 grams per 100 grams) than most other vegetables. It provides many of the essential amino acids important to human health. Sweet corn is a good source of vitamin C, vitamin B6, folate, thiamin, niacin, potassium, phosphorus, magnesium, iron, and manganese. One hundred grams (3.5 oz) of fresh sweet corn kernels consist of 3.3 grams of protein, 1.4 grams of fat, and 2 grams of dietary fiber. Fresh kernels are 76 percent water.

SWISS CHARD



Swiss chard (*Beta vulgaris*) is derived from the same species as table beets, but does not grow an enlarged root. Instead, the leaves are used for potherbs and salads. The crop has been selected to produce large, fleshy leaves, sometimes with colored stems, veins, and midribs. Swiss chard originated in western Europe and the Mediterranean region. It is a very popular crop in much of northern Europe.

Growing suggestions

Swiss chard will produce for a good portion of the summer if the leaves are frequently cut back or harvested. After old leaves are removed, the plant will produce tender, flavorful new leaves.

Soil type and soil preparation

Swiss chard will grow in almost any type of soil. For production of the best quality leaves, the soil must be fertile and have adequate organic matter. Swiss chard can be planted very early in the spring. Consequently, it is important to make sure the soil is not too wet when tilling. The soil should be damp but not wet. A ball of soil formed by squeezing in the hand should crumble easily under finger pressure.

Planting

Swiss chard can withstand moderate frost (down to 26°F) when the seedlings are small. Seed can be planted up to 2 weeks before last average frost. For best emergence, the daytime soil temperature should approach 50°F.

Planting specifications:

- Seed spacing: 1.25–2 inches
- Final spacing: 6–12 inches
- Ounces of seed per foot: 0.01
- Row width: 18–24 inches
- Seed depth: 1 inch
- Germination: 7–10 days

Fertilizer

Swiss chard has a fairly high demand for N in order to keep new growth vigorous and succulent. If you plan to harvest over a long period of the summer, apply fertilizer twice. Apply the equivalent

of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or product with similar ratios) is usually appropriate. Sidedress an additional 0.25 lb N at first harvest. Nitrogen is the most important nutrient for the sidedress fertilizer application, so a product made up primarily of N (21-0-0 or 46-0-0) is appropriate.

Weed control

Season-long weed control is important for Swiss chard, as it does not compete well with weeds. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. At all stages of growth, tillage activities close to plants should be shallow in order to prevent damage to roots.

Irrigation

Swiss chard has a shallow root system and little tolerance of drought stress. Even short, sporadic water deficits will cause the leaves to become fibrous and tough. Optimal irrigation entails frequent, small applications of water. On clay or loam soils, apply 1 to 1.5 inches of water every 3 to 5 days. On sandy soils, apply smaller amounts, but more frequently.

Insects

Insects rarely become a serious problem on Swiss chard. Occasionally, aphids or other leaf-chewing insects (such as blister beetles, loopers, armyworms, spotted blister beetles, or leafminers) cause sufficient damage to require control. Insecticidal soap or a range of organic or traditional insecticides will control most insects. The most difficult insects to control are leafminers. They reside inside the leaves, where they are difficult to treat. The best strategy often is to remove and destroy damaged leaves and allow new leaves to grow in their place.

Diseases

There are few or no serious diseases of Swiss chard in Idaho. Occasionally, plants become infected with curly top, a virus. Remove and destroy malformed or mottled plants.

Harvest

Remove large, succulent leaves by cutting near the base with a sharp knife. Take care not to damage the new inner leaves.

Storage

Swiss chard is usually cooked or eaten immediately after harvest. It will retain adequate quality for 2 or 3 days under humid refrigerated conditions.

Consumptive yield

Compute household planting requirements as follows:

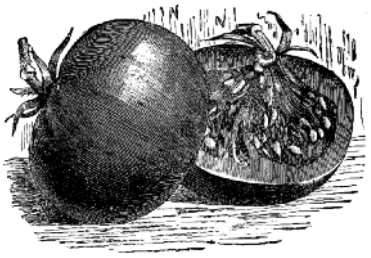
- 1.5–3 lb fresh Swiss chard per person
- Each foot of row will yield 0.8 lb.

Plant 2–4 feet of row per person.

Nutritive value

For a succulent, leafy vegetable, Swiss chard is surprisingly high in nutrients. It is extremely high in vitamin K, which is purported to protect brain activity and has a role in treating Alzheimer's patients. Swiss chard is an excellent source of vitamins A and C and a good source of vitamin E, vitamin B6, riboflavin, potassium, magnesium, manganese, iron, phosphorus, and calcium. One hundred grams (3.5 oz) of freshly harvested Swiss chard contain 1.8 grams of protein, 0.2 gram of fat, 3.7 grams of carbohydrates, 19 calories, and 1.6 grams of dietary fiber. Fresh chard consists of 93 percent water.

TOMATOES



Tomatoes (*Lycopersicon lycopersicum*) are one of the most commonly grown crops in home gardens around the world. Almost any small space can be utilized to grow significant quantities of this popular vegetable. Tomatoes originated in the tropical deserts of coastal Ecuador, Peru, and Chile. Archeological evidence suggests that they first found consistent use by humans in Mexico.

In short-season climates of northern and southeastern Idaho, the single most important production decision is choice of cultivar. Only the earliest cultivars should be used. (Remember, the word "early" in the name does not necessarily equal early in the garden.) The earliest cultivars usually

produce fairly small fruit. Multiple varieties can be planted to provide both early fruit and larger, higher quality fruit later in the season. In the warmer climate of southwestern Idaho, cultivar choice is less important, although early cultivars can still be used to bring tomatoes to the table sooner.

Tomatoes vary widely in growth habit. "Determinate" cultivars are very short, set fruit early, and tend to ripen the fruit over a short period of time. "Indeterminate" cultivars are viny and tall. They tend to set fruit continuously over the summer, mature a few fruit at a time, and reach maximum production very late in the summer. "Semi-determinate" cultivars are intermediate between the two growth habit classes. Determinate cultivars tend to be more useful in short-season climates because of their earlier maturity. However, there are exceptions; some indeterminate cultivars, especially cherry tomatoes, set and mature their first fruit fairly early.

Tomato cultivars have been developed for specific uses. Tomatoes developed for fresh use have a good balance of sugars and acids to create a good flavor. The fruits have large cavities that are filled with gel and seeds to produce juiciness. Processing or sauce tomatoes are starchy and have very thick walls, making them high in solids and low in water. They are much easier to cook down to a thickened processed product. Match the class of tomato to the intended use when choosing cultivars.

Heirloom tomato varieties are becoming very popular. These old varieties offer gardeners a wide array of unique production options. Heirloom plants are available in all maturity classes and growth habits. Fruits come in many sizes, colors, shapes, and flavors. Most heirloom varieties lack resistance to pests and disease, in comparison with modern hybrids, but offer other advantages.

Growing suggestions

Both heat and sunlight markedly improve earliness in tomatoes. Planting tomatoes in full sunlight is critical to encouraging early fruit ripening. You can provide warmer growing conditions by planting next to a south-facing structure, planting on black plastic, or using row covers.

Tomatoes are very sensitive to fertilizer applications, especially N fertilizers. High levels of fertility dramatically delay fruit set and ripening. If your goal is early-maturing fruit, maintain low levels of soil fertility. If a long season of production is desired (not possible in the short-season areas of Idaho), maintain higher levels of soil fertility.

Pruning tomato plants can enhance earliness and increase fruit size. Allow plants to grow unhindered until the first flush of fruits is set and increasing in size. At that time, begin removing all newly formed shoots from the plants.

Soil type and soil preparation

Tomatoes can be grown in most types of soil, but do best in lighter, sandy loams and loamy sands. Not only will plants be healthier on lighter soils, but fruits will mature more quickly. Clay soils must be managed to avoid frequent saturation in order to prevent root, stem, and fruit rots.

Tomatoes do best in soil with sufficient organic matter. If soil is low in organic matter, amend it with compost or manure (the previous fall, if possible). Work soil well to produce a deep, friable bed. Good soil tilth helps tomato plants develop a healthy root system.

Planting

Tomatoes are almost always transplanted rather than planted as seed. Transplanting enhances earliness, reduces problems with seedling diseases, and helps with weed control. Fortunately, tomatoes are very easy to transplant.

Unlike many other crops, tomatoes can be transplanted as very large plants. The larger the transplant, the quicker the plant will produce and mature fruit. Regardless of size, tomato transplants should be healthy, dark green, and growing vigorously. If transplants are tall or spindly, plant them deeply enough to leave only the leafy part of the stem exposed. Roots will form along the buried segment of stem.

Tomato transplants are damaged or killed by very light frost. Consequently, if planted early, they must be protected. A variety of season-extending products (hot caps, water sleeves, milk jugs, row covers, etc.) is available. If protection is provided, tomatoes can be transplanted shortly after the average last frost date. Otherwise, delay transplanting by about 2 weeks.

To grow unusual or heirloom varieties, you may need to produce your own transplants. Plant seed indoors 5 to 7 weeks before the projected transplant date. The most difficult aspect of producing transplants without a greenhouse is providing adequate light to keep the seedlings healthy and compact. It is best to provide both a window with southern exposure and artificial lighting.

Transplanting specifications:

- Final spacing (determinate): 18 inches
- Final spacing (indeterminate): 30 inches
- Row width (determinate): 36 inches
- Row width (indeterminate): 36–48 inches

Fertilizer

Tomatoes have a reputation as heavy users of nutrients. In climates with long, warm seasons, this is true. In short-season climates, the tendency for delayed maturity under conditions of high fertility makes it necessary to limit the amount of added fertilizer (specifically N).

Tomatoes respond positively to adequate levels of P and K. A 5-10-10 fertilizer formulation (or similar product with low N ratio) is usually best. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. In short-season climates, this application will be sufficient to bring the crop to harvest; additional fertilizer will serve only to delay maturity. In longer season climates, enhance late-season production by sidedressing an additional 0.2 lb N at first harvest. A third application of 0.1 lb N in early August may be beneficial in places where production continues into September or later. Nitrogen is the most important nutrient for the sidedress fertilizer applications, so a product made up primarily of N (21-0-0 or 46-0-0) is appropriate.

Weed control

Early-season weed control is important for tomatoes. Once established, plants compete well with weeds. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. At all stages of growth, tillage activities close to plants should be shallow in order to prevent damage to roots.

Irrigation

Young tomato plants have a relatively shallow root system and little tolerance of drought stress. Improper irrigation not only reduces productivity, it encourages the development of a fruit-destroying condition known as blossom end rot (a black, leathery patch on the bottom of the fruit). Early in the season, optimal irrigation entails relatively frequent, small applications of water. On clay or loam soils, apply 1 to 1.5 inches of water every 3 to 5 days. On sandy soils, apply smaller amounts, but more frequently. As plants mature, irrigation can become less frequent, although the soil should remain evenly damp.

Insects

Only a few insects routinely affect tomatoes. The most damaging is the tomato hornworm. This large caterpillar can defoliate an entire plant within a day or two. Luckily, hornworms do not appear in large numbers and can usually be removed by hand and destroyed. Colorado potato beetles may damage leaves; they can also be controlled by hand removal or application of an approved insecticide. Spider mites occasionally become a problem in hot weather. They are best controlled by irrigating with overhead sprinklers or frequently spraying the plants with water.

Diseases

Tomatoes are prone to a number of very serious diseases. Curly top is a virus that appears frequently in Idaho gardens. This virus causes the youngest leaves on the plant to curl and become malformed. It does not spread from one plant to another, so it can be ignored if not serious. If it affects productivity, remove diseased plants so they do not compete with healthy plants.

A soil fungal disease called verticillium wilt often causes plants to become weak, turn yellow, and develop burned leaf edges. This disease is very common in southern Idaho. Other than planting resistant cultivars (usually designated with a “V” following the name), the only treatment is to practice crop rotation.

A number of leaf-spotting and leaf-drop diseases affect tomatoes, including early blight, late blight, and septoria. Early blight and septoria leaf spots start on the oldest leaves and may move very slowly up the canopy. If symptoms become severe before midseason, it may be necessary to apply a labeled fungicide. Late blight, although somewhat rare, can rapidly kill plants under the right conditions (cool, cloudy, rainy). If present, multiple applications of a

good fungicide are required. Because of the threat to potato crops, public media in Idaho deliver warnings when late blight is a local issue. This information will help guide control decisions. It may be necessary to get professional help to distinguish among the tomato leaf-spotting diseases.

Fruit rots often damage the crop as it nears harvest. These fungal and bacterial diseases are best controlled by avoiding over-watering and staking the plants to keep the fruit off the ground.

Harvest

Fruits can be harvested at any time after they begin to turn pink (assuming the cultivar's mature fruit is red). The best quality fruits with the fullest flavor are those that ripen fully on the vine.

Storage

Store unripe fruit at 50 to 60°F in a relatively dry room. These conditions allow slow and steady maturation and color development. Fully ripe tomatoes can be stored for several days at 50°F with high humidity. They can be stored in the refrigerator for up to 2 weeks, but must be used immediately upon removal due to injury and degradation that occur at cold temperatures.

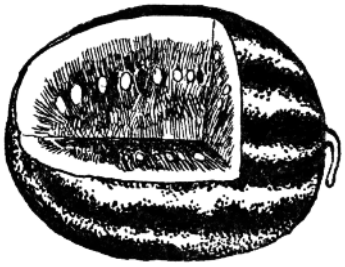
Consumptive yield

The required quantity of planted tomatoes varies widely, depending on how they are used. If intended strictly for fresh use, one healthy tomato plant can supply the needs of several people. If used to produce sauces, salsas, and other products, several feet of row may be required for each person. Experience will help define needs.

Nutritive value

Red tomatoes contain lycopene, which has been shown to protect skin from damage due to UV rays. Tomato fruits are also a good source of vitamin A, vitamin C, vitamin B6, vitamin K, potassium, and manganese. One hundred grams (3.5 oz) of fresh tomatoes contain 0.9 gram of protein, 0.2 gram of fat, 3.9 grams of carbohydrates, 82 calories, and 1.2 grams of dietary fiber. Fresh tomatoes consist of 95 percent water.

WATERMELONS



Watermelons (*Citrullus lanatus*) are native to the savannah regions of Africa, where they were used as much for their water content as for their nutrition. They can be a challenge to grow in all but the warmest climates of southwestern Idaho. In short-season climates, they are the epitome of a green-thumb challenge. Regardless of where you live, they are a fitting treat in the heat of late summer.

Most watermelon cultivars are suitable for production in the south-central and southwestern regions of the state. In all other areas, it is important to select early-maturing cultivars. Even then, many cultivars developed for earliness in other parts of the country (e.g., Sugar Baby and New Hampshire Midget) do not produce quality melons in Idaho because they are not adapted to cool summer nights. Some of the best melons for short-season areas of Idaho are the yellow-flesh icebox types (e.g., Early Moonbeam, Yellow Doll, and Yellow Baby).

Growing suggestions

Watermelons are suitable only for fairly large gardens. They do not require as much room as pumpkins or winter squash, but each plant still needs at least 30 to 40 square feet to produce well. Fruit will not size well if plants must compete with tall or dense plants of other crops.

Watermelons require full sun all day long to produce their sweetest fruit. Shade not only results in inferior flavor, but delays maturity, making production in marginal climates even more difficult.

Watermelons are truly a warm-season crop. Not only are they extremely sensitive to frost, they are injured by temperatures as high as 35°F. It is critical to be patient in waiting for warm, late-spring weather before planting watermelons in the garden. Also, it helps to provide warm growing conditions by planting next to a south-facing structure, planting on black plastic, and/or using row covers.

Soil type and soil preparation

Watermelons are best adapted to lighter soils—sandy loams and loamy sands. They grow faster, mature earlier, and produce the best quality melons on these soils. However, they can be grown on any soil, as long as irrigation is managed to avoid frequent saturation. Watermelons do not require large amounts of organic matter in the soil.

Planting

Transplanting is an option in order to enhance earliness. However, due to physiological problems created by transplanting, watermelons often produce better if planted directly from seed, even in cold climates. Plant seed 2 to 3 weeks after average last frost, and then only if daytime soil temperatures are at least 70°F.

Transplanting can be successful if all conditions are correct. Most importantly, use transplants that are healthy and at the right stage of growth. Transplants must be small, rapidly growing, and dark green. A root-hardening response common to this family of plants slows or prevents new growth of less-than-ideal transplants. Transplants that are too old, etiolated, or slow-growing, or those that have been stressed at any time for water or nutrients, seldom produce a vigorous plant.

Place transplants in the garden 2 to 3 weeks after last average frost and when the forecast is for mild weather. Once a healthy transplant has been placed in the garden, it must be protected from wind, sun, and cold, even if growing conditions are ideal.

Planting specifications:

- Seeds per hill: 3–5
- Distance between hills: 4–5 feet*
- Final stand per hill: 2–3
- Ounces of seed per foot: 0.05
- Row width: 6–8 feet
- Seed depth: 1 inch
- Germination: 5–14 days

**Hill spacing for transplants is the same as for seed.*

Fertilizer

Watermelons are heavy feeders and respond positively to adequate levels of N, P, and K. Split applications work best to keep watermelons growing vigorously throughout the season. Apply the equivalent of 0.25 lb N (in combination with P and K) per 100 square feet during soil preparation. A 10-10-10 fertilizer formulation (or product with similar nutrient ratios) is usually adequate. Sidedress an additional 0.3 lb N when the plants begin to form running vines. For sidedressing, select a high-N source such as 21-0-0 or 46-0-0.

Weed control

Watermelons do not compete well with weeds at any stage of growth. Consequently, season-long weed control is required. Control weeds through mechanical tillage, hand weeding, or use of a labeled garden herbicide. At all stages of growth, tillage activities close to plants should be shallow in order to prevent damage to roots. Avoid damage to the vines during weed-control efforts.

Irrigation

As they grow, watermelons develop relatively deep, vigorous root systems. Plants will produce the best quality melons if not over-irrigated. Irrigation should be deep and infrequent in comparison with most garden crops. Once plants are established and growing well, weekly applications of 2 to 2.5 inches of water are usually adequate. On very sandy soils, apply smaller amounts, but more frequently.

Insects

Cutworms are the most common pest of watermelons in Idaho gardens. They emerge from the soil at night and cut down newly emerged seedlings. Consistent problems with cutworms may require application of a labeled soil insecticide prior to soil preparation. Spider mites occasionally become problematic and are best controlled by using overhead sprinkler irrigation. Occasionally, application of a miticide may be necessary.

Diseases

Many diseases affect watermelons in humid climates, but the dry air in Idaho limits these problems. In gardens where watermelons, cucumbers, cantaloupes, and squash are frequently grown, a soil-borne disease called fusarium wilt can build up. This fungus causes plants to remain small, become weak, turn yellow, develop burned leaf edges, and eventually die early. Partial prevention is possible by practicing crop rotation with at least 4-year intervals. Watermelons are also very susceptible to root rots if they are over-irrigated or planted in poorly drained soil.

A few viral diseases, such as curly top, occasionally appear on watermelons. Symptoms include malformed leaves and fruit, mosaic color patterns on the leaves, and general yellowing or stunting. Remove and destroy plants showing these symptoms to prevent competition with healthy plants.

A physiological fruit rot (not caused by fungi or bacteria) called blossom-end rot occasionally appears on watermelons. It is typified by a black, leathery patch on the end of the fruit opposite the stem. It is caused by repeated drought stress. Proper irrigation usually alleviates this problem.

Harvest

It is important to pick watermelons when fully ripe because they will not finish ripening off the vine. Knowing when to pick a watermelon is an art unto itself, and no one is successful all of the time. However, there are three fruit-related signs that will make the decision easier. First, as a melon ripens, the ground spot (the spot on the melon that is in contact with the soil) will turn from white to yellow. Second, a ripe melon will display a dried-up vine tendril. Follow the stem of the fruit to the vine. At the point of attachment, you will see a leaf and a tendril. The tendril is a "curly-cue" that the plant uses to grab and climb. This tendril will dry up when the fruit is ripe. Third, small wasps will sting a ripe watermelon, causing the development of small (usually less than 1 inch in diameter) rings or target spots on the top of the fruit. Additionally, if you are a good watermelon "thumper," the sound of a melon does deepen as the fruit ripens, providing a final test for ripeness.

Storage

Watermelons are usually not stored for any significant length of time. However, they can be held in a cool, unrefrigerated place for a week or more without losing quality. Once cut, the melon should be refrigerated and consumed within a few days.

Consumptive yield

Compute household planting requirements as follows:

- 3–6 lb fresh watermelon per person
- Each foot of row will yield 0.5 lb.

Plant 6–12 feet of row per person.

Nutritive value

Fresh watermelon consists of 92 percent water. Due to this high water content, watermelons are relatively low in nutrients, but they are a good source of vitamin C and have trace amounts of many other vitamins and minerals. One hundred grams (3.5 oz) of fresh watermelon contain 0.6 gram of protein, 0.2 gram of fat, 7.6 grams of carbohydrates, 30 calories, and 0.4 gram of dietary fiber.

FURTHER READING AND RESOURCES

Source of nutritional information: USDA/ARS Nutrient Data Laboratory, SR-23 databases. http://www.nal.usda.gov/fnic/foodcomp/search/

Additional source of health benefits information: *Nutrition and You.* http://www.nutrition-and-you.com/vegetable-nutrition.html

University of Idaho Extension Publications

Most UI Extension publications are available to download for free at http://www.cals.uidaho.edu/edcomm/catalog.asp.

Ones in print can be ordered online or by calling (208) 885-7982 or emailing calspubs@uidaho.edu.

Blossom-End Rot of Tomatoes (CIS 292) in print only

Choosing and Growing Adapted Vegetable Varieties (BUL 863) online only

Growing Tomatoes in Cool, Short-Season Locations (BUL 864) online only

Growing Vegetable Seedlings for Transplanting (CIS 800) in print only

Harvesting and Storing Fresh Garden Vegetables (BUL 617) online and in print

Management of Vegetable Diseases in Home Gardens (CIS 993) online and in print

Options for Storing Potatoes at Home (CIS 1153) online only

Planning an Idaho Vegetable Garden (BUL 775) online and in print

Potato Production in the Home Garden (CIS 1000) online and in print

Short-Season Vegetable Gardening (PNW 497) online and in print

Sweet Corn Production for the Small Market Grower and Home Gardener (CIS 910) in print only

Tomatoes for the Home Garden (CIS 667) online and in print

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Chapter 22
Fruit Trees

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I. Introduction

Growing fruit can be an important part of home gardening, but it demands a year-round and year-to-year commitment by the gardener. In addition to the personal satisfaction and enjoyment of tree ripened fruits, fruit trees have considerable landscape value. Properly cared for, they are attractive in form and display beautiful flowers in the spring. If judiciously placed, they can enhance a well-designed landscape.

II. Site Selection

An ideal location for fruit trees:

A. Is Without Frost Pockets—A gentle slope with good air drainage will work well. Plant the trees three-quarters of the way down the hill. Cold air will drain down the hill and will help limit frost damage in the spring (Fig. 1). Frost damage can occur any time from bloom to late spring.

Frost damage to blossoms is a likely problem, particularyly with early blooming fruit trees (Table 1). For example, apricots may produce a crop only once every 5 years because of early spring frosts. Small fruit may fall off soon after a killing frost. Stone fruit, such as peaches, may stay on the tree until mid to late June, and then drop. Diagnose for frost damage by cutting open the small fruit. If the ovules (the portion that becomes the seed) are brown, the fruit is dead.

Fig. 1. Frost damage is best prevented by proper site selection. Choose a gentle slope with good air drainage.

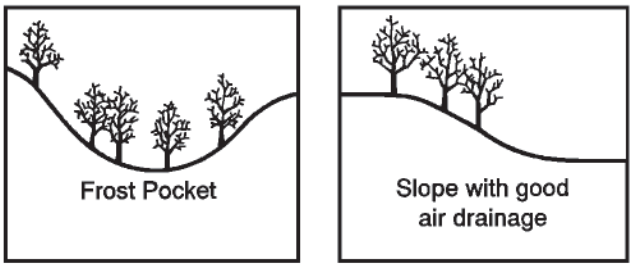


Table 1. Usual order of bloom in fruit trees.

Earliest	Apricots
	Japanese plums
	Peaches
	Oriental pears
	Italian plums
	Cherries
	Pears
Latest	Apples

B. Is in Full Sun—Fruit trees should be planted well away from areas of shade such as large trees and buildings. Not only must the tree itself receive full sun, but it must also be properly pruned so that light can penetrate to the inner leaves. This is necessary in order to maintain good flower production and fruit set throughout the tree.

C. Has Well-Drained But Not Droughty Soil—A site with deep, fertile, sandy loam soil increases the probability of successful tree growth and fruit production. A site with poor drainage increases the probability of winter injury to fruit trees. A drainage problem, such as a perched water table, can be lessened by breaking through the hard pan layer in the soil. Stone fruits, particularly peaches, do not tolerate "wet feet."

III. Fruit and Nut Cultivars for Idaho

Once the decision is made to start a home orchard, a lot of thought must go into cultivar selection. Cultivars must be adapted to the climate and soils of your specific area, must provide fruit at the desired time, and must be suited to uses such as freezing, canning, and preserving. Select cultivars that will extend the harvest season from July through October. Since some cultivars are easier to grow than others, choose only the ones you, your family, and friends really appreciate so your horticultural efforts will be justified. In addition to local expertise, "Western Fruit Berries & Nuts—How to Select, Grow, and Enjoy," is a good reference. Some cultivars can be ordered if you give your local nursery enough notice.

Note: Fruit and nut trees are propagated either by grafting or budding to obtain true-to-name trees. A seedling fruit tree cannot produce the same kind or quality fruit as its parent and it comes into production much later.

IV. Types of Tree Fruits

The complexity of tree fruits can be simplified for study by grouping tree fruits into two categories: pome fruits and stone fruits. Both pome fruits—apples (Malus) and pears (Pyrus)—share many cultural similarities and pest problems. The stone fruits (Prunus)—apricots, cherries, nectarines, peaches, and plums—share cultural similarities.

A. Pome Fruits (Apples and Pears)

1. Apple trees are among the most cold tolerant fruit trees, but climate adaptability varies according to cultivar. In colder areas of Idaho, it is best to plant mid-season cultivars that will escape spring frosts and ripen before extreme cold in the fall.

   The best vegetative growth and optimal fruit production are obtained in well-drained, deep soil.

   Many apple cultivars require a second cultivar for cross-pollination by bees to ensure adequate crops. Crab apples can also cross-pollinate apple cultivars. Bloom times of the cultivars need to overlap to ensure pollination.

   Choose cultivars to grow at home that are not readily available in your local grocery store, that you especially enjoy, and that are best for your purpose.

   Less commonly grown cultivar suggestions are:

   a. *King*: Large, waxy yellow with red striping. Crisp and sweet. Good for eating and baking.
   b. *Northern Spy*: Large, red apple with tender, fine-grained flesh. One of the finest for flavor. Stores well. The tree is slow to reach bearing age, and tends to bear alternate years.
   c. *Spitzenberg*: Medium, red with yellow dots. Crisp, fine-grained flesh with a tangy, spicy flavor.
   d. *Wealthy*: Red-tinted white flesh and a deserved reputation for quality. Good cooking apple; satisfactory for fresh use. It is a particularly good tree for colder areas. Tends to bear alternate years. Good pollinizer for other apples.
   e. *Winesap*: Large, round, and with a lively flavor, these apples make good desserts. An old-timer that remains a favorite. The trees are vigorous, and are early, reliable bearers.

2. Pears will tolerate poor drainage and neglect better than other fruit trees. For best vegetative growth and optimal fruit production, pears should be planted in a well-drained, deep soil and spaced about 16 to 18 feet apart.

   The major problem with pears is fire blight, which primarily attacks young, vigorous wood. Treatment is to cut out and destroy the blackened diseased wood. Train and prune trees only to shape them, limiting cuts to smaller branches as much as possible. Excessive pruning can stimulate vigorous, susceptible growth. Heavy rain during bloom as well as hail-inflicted wounds will increase the chances of fire blight infections. To lessen the incidence of the disease, application of copper can be made during the delayed dormant stage. This will reduce the bacterial inoculum levels on the surface of the tree.

Avoid the use of nitrogen fertilizer unless trees show obvious signs of a deficiency. Excess nitrogen application promotes vigorous growth that will then be vulnerable to fire blight.

Cultivar suggestions include:

a. *Bartlett*: A standard commercial variety, matures toward the end of summer and has excellent fresh eating as well as canning quality.
b. *Bosc*: A fine-flavored dessert variety ripening after Bartlett.
c. *Clapps Favorite*: Matures before Bartlett and is the earliest pear of good quality.
d. *Seckel*: A small gourmet pear with a russet skin; a pickling as well as a dessert pear.

B. Stone Fruits

1. Apricots—Flower very early in spring; consequently, the occurrence of spring frost will affect fruit production. It may help to plant apricots on a northern exposure (but not in shade) to delay bloom, but a safer course of action is to choose later-blooming cultivars. Bloom and maturity dates vary, depending on area, cultural practices, tree age, and season.
2. Cherries—Do best in deep, well-drained soil. Space sweet cherries about 30 feet apart. The trees may not fill that much space, but the cherry fruits need sunlight to ripen.

   Most sweet cherry cultivars need an aid in pollinating in order to produce fruit, so choose the second tree carefully.

   Black Tartarian, Corum, Republican, Sam, and Van will pollinate any other cherry tree. Stella, Compact Stella, and Garden Bing are self-fertilizing and require no second tree for pollination. Bing, Lambert, and Royal Ann will not produce fruit in any combination.

   The most dependable cherries for colder areas of Idaho are the sour type that are self-fertilizing. Montmorency is the most popular cultivar for the home garden as well as being a leader in commercial sour cherry production. Sour cherry trees may be planted 20 feet apart.
3. Peaches and nectarines—Differ in their tolerance of cold or mild winters. Be sure to select cultivars that are adapted to your climate.

   Generally, there is a risk of damage where winter temperatures fall below -10° to -15°F. Trees planted on a hillside where the coldest air drains to low-lying areas or trees planted near large bodies of water may tolerate areas otherwise too cold for them.

   Reliance and Polly (Haven Polly) are considered some of the hardiest peach cultivars. Nectarines are more tender than peaches.

   Peaches and nectarines are generally self-fruitful, or self-pollinating.
4. Plums and prunes—The most popular cultivars are derived from either European or Japanese species. These cultivars can grow 15 to 20 feet high and about as wide. European varieties bloom late and are better adapted to areas with late frost or cool, rainy spring weather than are the early-blooming Japanese varieties. Many plum and prune cultivars need another cultivar growing nearby for pollination.

   The European-type plum, called the Italian prune, is a high yielder, requires no thinning, hangs on the tree, and ripens to a taste treat that more than justifies its place in the home garden.

C. Nuts

1. Filberts or hazelnuts—These make an attractive, small tree for the garden. Spring to fall, the roundish, ruffled-edged leaves cast a pleasant spot of shade. Showy male catkins hang long and full on bare branches in winter. Female flowers are small and red in color. A crop of round or oblong nuts comes as a bonus in the fall.

   Plant trees in early spring in well-drained, soil and plant at least two compatible cultivars for cross-pollination.

   Filberts tend to sucker. If you wish to maintain a single trunk, remove these shoots three to four times a year. Filberts can also be grown as a bush.
2. The Persian (English) walnut—Should not be planted as a landscape tree except

on a large lot with deep soil. Established trees take some drought, but deep, regular watering is required. Older trees need pruning only to remove dead wood. Plant walnut trees 40 to 60 feet apart. Walnut flowers are susceptible to spring frosts.

3. Almonds—Will survive in southwestern Idaho, but don't produce annual crops because they bloom early in the spring and are usually killed by frost.

V. Rootstock

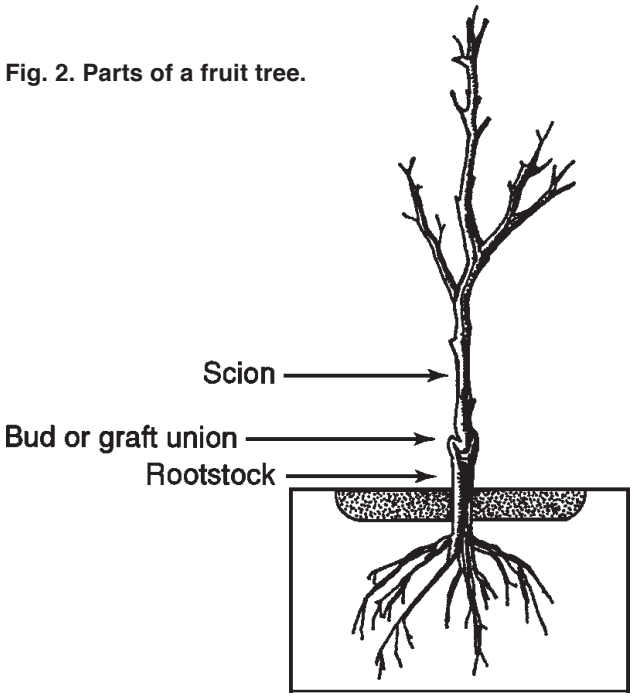
Fruit trees consist of two parts: a scion and a rootstock. The scion, or fruiting cultivar, is the most above-ground part of the tree. It is grafted or budded onto a rootstock to form a new tree (Fig. 2). This tree is the same cultivar as the scion and will produce fruit of that cultivar. A wide range of rootstock, varying in size as well as other attributes, are available for apples. However, rootstock selections for other tree fruit are more limited.

Dwarfing rootstock is preferred since it produces a more compact fruit tree. It bears fruit earlier in its life, is easier to prune and spray, and is easier to harvest.

A. Apples

Apple tree growth may be manipulated to three basic sizes: standard, semi-dwarf, and dwarf.

Fig. 2. Parts of a fruit tree.



1. The standard (seedling) rootstock is adaptable to most conditions. It has an extensive root system and should be planted about 20 feet apart.
2. The semidwarf rootstock (MM-111, MM-106, and EM-7) make a tree one-half to two-thirds the size of a standard tree.
3. The dwarf rootstock (M-26 and EM-9) make a tree one-third to one-half the size of a standard tree. The more dwarfing the apple rootstock, the more support the tree will require. When the tree is bearing a crop, dwarfing rootstock (M-9 and M-26) will need a stake to hold the tree up in the wind. In general, the more dwarfing the rootstock, the faster the tree will bear. It is important to allow sufficient vegetative growth to fill the space before allowing the crop to slow vegetative growth.

B. Pears

Pear cultivars are available on semidwarf or seedling rootstock. The seedling rootstock are hardier than other rootstock, making larger but more manageable trees.

C. Stone Fruits

Nectarines, peaches, and apricots are grown on seedling rootstock and form fruit on 1-year-old wood. It is easy to keep them the desired size by pruning and still have fruit production on seedling stock. Cherry trees produce large canopies. There is no such thing as a true dwarf cherry. Semidwarf trees on Mahaleb rootstock reduce tree size a maximum of only 10 percent. Work is being done to develop a rootstock that will reduce size, but the end results are a few years away.

VI. Cultural Practices and Problems

A. Planting

Fruit trees may be planted in the fall or spring. Bare root trees are usually available only in the spring. Planting early in the season before the roots dry out will ensure the best success. With containerized trees, the time of planting is less critical. Follow these steps to plant a fruit tree:

1. Dig a planting pit with vertical sides and make it large enough to accommodate the

root system without crowding. The pit should be a minimum of 2 to 3 feet deep and should allow at least a 6-inch clearance from the end of the roots.

2. After removing all broken or damaged roots, place the tree in the planting pit. Spread the planting soil around the tree and tamp to firm. Use planting soil that is as good or better than the soil in which the tree originally grew. Avoid using planting soil around the tree that is so different from the native soil that water and roots either do not penetrate the native soil, or that water runs around the planting soil in the pit and into the native soil.
3. Pour water into the planting pit until the consistency of thick liquid is attained. Gently raise and lower the tree to allow the soil to fill between the fibrous roots and to eliminate air pockets. Add water and planting soil alternately until the pit is filled to grade.
4. The tree should rest at the depth at which it grew in the nursery, and the bud union (the place where the tree was budded in the nursery) should be about 6 inches above the soil level after planting. A collar at the base of the tree, lighter in color than the rest of the trunk, indicates the original growing depth.

B. Training and Pruning

Both can influence apical dominance, or the tendency for the apex (uppermost bud) to grow more rapidly than the lower buds. Apical dominance is thought to be caused by a hormonal stimulus produced by the growing apex that suppresses the development of lateral bud growth. Cuts on higher or lower parts of the tree will have differing results in vegetative growth depending on the distance from the apex.

1. Training—This is the process of giving desirable structure to fruit trees from 1 to 4 years after planting. The objective of training young trees is to establish the essential structure of the tree and to bring the tree into bearing.
2. Pruning—This is used to maintain the shape of trees 3 or 4 years after planting as well as after trees are bearing fruit.

The objective of pruning older trees is either to open the trees to sunlight or to maintain fruiting by pruning back the overhanging limbs in the upper part of the tree, so that sunlight reaches the lower and inner portions of the tree.

There are two types of pruning cuts:

a. *Heading-back cut*: This is an invigorating cut that causes an increase in vegetative growth in the immediate area of the cut. Because the hormonal gradient is destroyed, the growth of the lateral buds is no longer suppressed.
b. *Thinning-out cut*: This type of cut removes shoots but does not stimulate vigorous regrowth. Because the hormonal gradient is not interrupted, vegetative growth continues. A thinning-out cut can also be used on upright and overhanging growth. This type of cut will result in an increased flower bud production over the whole tree.

Note: Excessive pruning, especially heading-back cuts, will delay fruiting in the early years and reduce fruiting on older trees.

3. Seasons of pruning—Trees can be pruned any time after the leaves fall in autumn and before bud break in the spring. Avoid making large saw cuts (over 3 inches in diameter) until hazardous winter temperatures are over. If you have only a few trees, resist the temptation to prune your trees on the first non-subzero day that seems warm enough to be doing something outside. Some commercial peach growers wait until bloom time to see what blossoms exist before they prune.
   a. *Winter (dormant) pruning*: The dormant period is the most desirable time to prune out broken, damaged, diseased, and weak wood; to remove limbs crossing over other limbs; or to eliminate narrow angled crotches. (Wide angled branch crotches of 45 to 90 degrees are the strongest.)
   b. *Summer pruning*: Trees can be pruned any time during the growing season.

Pruning during this period decreases the shoot growth and, therefore, is a common practice where better control of shoot growth is desired. Rub off or pull off water sprouts and suckers that shade the inner parts of the tree, fruits, and spurs. This should be done when shoots are 3 to 4 inches long and before they become woody. Shoot removal by pulling at this stage damages adventitious buds at the base of the shoot, which limits regrowth.

Note: Pruning after the first of September or before trees become dormant stimulates growth, making the trees more susceptible to winter injury during early fall freezes.

4. Pruning tips
   - Don't leave stubs! Cut close to the trunk at the branch collar. Cut back to a live branch or bud.
   - Don't paint wounds. Paint traps moisture and encourages rot. Slant cuts so rain runs off.
   - Remember, the art of pruning comes from knowing how and where to cut.

C. Water Management (Irrigation)

Soil moisture (e.g., not too much and not too little) is important in maintaining tree vigor, productivity, and fruit size.

1. Drought or moisture stress alone rarely kills healthy, well-established fruit trees. However, newly set trees with limited root systems or plants damaged by cold injury, diseases, or insects are more susceptible to moisture stress. Occasionally, a prolonged drought results in extensive feeder-root death, which destroys large trees. This is most severe in sandy soils with poor moisture-holding capacity.
2. Good soil drainage is important, especially in the spring. During the summer and early fall, the trees deplete the available soil moisture. Irrigation is usually required! Poor drainage is common in soils with a high clay content and dense, impervious subsoil, or in lowlands with a high water table.
3. Although fruit trees have deep root systems, most of the roots are concentrated in the upper 2 feet of soil and extend outward slightly beyond the spread of the limbs.
4. Oftentimes trees in lawns and under grass sod are irrigated to maintain a good grass cover, but insufficient water is applied to the root zone of the tree. Tree roots do not compete well with grass roots. To remedy this problem, clean out all grass growing under the dripline of any fruit tree.

Note: High soil moisture levels or frequent watering around the base of the trunk, particularly in heavy soils, can result in the development of crown rot, a fungal disease that attacks the roots and kills the tree. Overwatering by itself can also kill roots. Because oxygen is only partially soluble in water and becomes depleted under waterlogged conditions, the roots are asphyxiated. Root or crown damage from excess moisture turns inner-bark tissue brown. Often, damage is not apparent for several months, especially if the excess moisture occurs in late fall or early spring. Crown rot causes earlier leaf color change in the fall.

Note: Prunus species, including cherries, peaches, and nectarines, are most susceptible to death of feeder roots in poorly drained soils. Pears, apples, plums, and most small fruits are more tolerant to temporary excess soil moisture, but they can be severely injured or weakened by extended periods of very wet soil conditions.

D. Fertilization

Nutritional deficiencies are not a direct cause of tree death unless excessive or improper fertilizing results in tree damage. Normally, it is not advisable to fertilize at planting. Young tree roots are easily burned, and the tree may die back or die completely.

After growth has begun, however, use a complete fertilizer having essential nitrogen

Table 2. Recommended annual terminal growth of fruit trees.

Nonbearing trees	
Apple	24 to 36 inches
Pear	12 to 26 inches
Peach and other stone fruits	16 to 24 inches
Bearing trees	
Apple	12 to 14 inches
Pear	6 to 12 inches
Peach and other stone fruits	10 to 15 inches

(N), phosphorus (P), and potassium (K) or (N-P-K) with 10 percent N (such as 10-6-4 or 10-10-10), particularly in the sandy soils.

The amount of N to apply in late fall or early spring (preferably before bud break) depends upon the type of tree fruit and its productive status (Table 2). Much less than these recommended growth rates will result in reduced fruiting wood and a smaller crop the following year.

If you are just starting a fertilizer program, 1/8 pound of actual nitrogen should be soil applied to stone fruits for every inch of trunk diameter (measured 1 foot above ground level). In the case of pome fruits (apples and pears), 1/10 pound of actual nitrogen should be used for each inch of trunk diameter.

The actual amount of N differs among products, and this difference must be taken into account when computing the amount of fertilizer needed. For example, a 5-inch diameter peach tree will need 5/8 pound of actual nitrogen (A.N.):

diameter x pounds A.N. required =

5 x 1/8 = 5/8 lb (.625 lb) A.N. needed

If ammonium sulfate 20-0-0 (20% N) is used, 3 1/8 pound of fertilizer will be required to provide the N needed for a 5-inch peach tree:

$$\frac{\text{lb AN needed}}{\%\ \text{N}} = \frac{5/8\ \text{lb}}{20\%} = \frac{0.625}{0.20} = 3.125\ \text{lb}$$

In the case of ammonium nitrate at 33 percent N (33-0-0), a little over 1 7/8 pounds of ammonium nitrate is needed for the same 5-inch diameter peach tree:

$$\frac{\text{lb AN needed}}{\%\ \text{N}} = \frac{5/8\ \text{lb}}{33\%} = \frac{0.625}{0.33} = 1.89\ \text{lb}$$

The amount of nitrogen to be applied is determined by the amount of growth in the previous year. If too little growth is occurred, increase the nitrogen application. If too much growth occurred, reduce the nitrogen application. Knowing how much nitrogen to apply requires accurate record keeping.

Where organic mulches are used, the amount of N fertilizer may be decreased as the mulch begins to decay, releasing N. Fertilizing with manure is tricky because N and salt levels vary depending on the age and source of the manure.

Other nutrients need to be applied according to the results of a leaf analysis. Zinc, iron, and boron are micronutrients that are often deficient.

E. Insect and Disease Control

Success in growing fruit depends on effective control of insects and diseases, recognition of the common diseases and insects, selection of effective pesticides, proper timing of pesticide sprays, and thorough coverage of fruit and foliage with the spray mixture.

1. Organic control measures are available for some pests but, in general, their results are mixed.
2. Commercial fruit growers, because of the size of their operations, can afford to buy large equipment to effectively apply pesticides.
3. Home orchardists with a few fruit trees are at a disadvantage when it comes to obtaining equipment that will do a satisfactory job of spraying fruit trees. In most cases, they are restricted largely by the cost of hand-operated sprayers or those operated by small electric or gasoline motors. The capacity of these machines is small, the pressure is low, and the energy expended to do an effective job is considerable. Yet the homeowner fights the same pests, often on the same size trees, as the commercial grower.

4. It has been shown repeatedly that failure of homeowners to adequately control pests on their fruit trees can generally be attributed to not knowing what is causing the damage or what could cause the damage, not applying enough material to cover the trees completely, not making applications on time, and not continuing the spray program late enough into the summer.

Note: Dormant sprays are an important step in controlling insects and diseases. However, there are different dormant sprays; some control only diseases, while others control only insects. Consult the *Pacific Northwest Insect Control Handbook* and the *Pacific Northwest Plant Disease Control Handbook* for specific recommendations.

F. Rodent and Deer Damage

Fruit trees are susceptible to mouse, gopher, and deer damage.

1. Mice—Eat the bark of the trunk and roots near the soil surface. Damage is easily detected by removing soil from around the base of the tree and the larger roots near the surface. Bark completely removed by gnawing rodents will girdle, weaken, and finally kill the tree. As with other types of mechanical injury, plants weakened but not killed by rodents are more susceptible to drought, cold injury, disease infections, and insect infestations.

   To reduce the hazard of mouse damage, clean out all grass and weeds in a 3- to 4-foot diameter circle around the trunk of the tree. This rids the area of ground cover that might protect mice from predators. Wire guards, constructed from fine wire mesh and placed 1-inch deep in the soil, are effective around young trees.
2. Gophers—Are best controlled in the home garden by trapping. Poisoned baits are available for mouse and gopher control.
3. Deer—May damage fruit trees planted near woods or other areas with adequate deer cover. Deer feeding on young growing shoots and buds of fruit trees can severely stunt and weaken the plants. In the late summer and fall, buck deer often break and kill young trees while rubbing the velvet from their antlers. Tall fences or repeated use of approved repellents may be required for adequate deer damage control.
4. Moles can sometimes present problems by burrowing directly under trees. In this case, roots dry out and tunnels are used by mice who feed on the roots. Moles do not feed on tree roots.

G. Vegetation Management Due to Weed and Herbicide Injury

Weeds weaken fruit trees by competing for soil moisture and nutrients. The wise combination of cultivation and approved herbicides helps reduce weed competition.

Improper or excessive herbicide use frequently causes fruit tree death. Contact-action herbicides, when misused and allowed to drift onto foliage or tender green bark, can severely injure and ultimately kill the plant. Similarly, systemically absorbed herbicides for weeds can be lethal to fruit plants when improperly sprayed.

Long term use of the same soil-residual herbicide may eventually result in excessive soil accumulation, causing root injury, plant weakening, or death.

Do not plant fruit trees on sites immediately after corn or grain crops where a persistent herbicide, such as atrazine, was used for weed control. Fallow the soil for one or two growing seasons before planting fruit trees. This allows herbicide degradation and prevents tree injury or death.

Herbicides are safe, effective tools for reducing weeds in fruit crop planting. To prevent herbicide damage or plant death, pay careful attention to label guidelines for application, apply the correct rates, and use only herbicides approved for specific fruit crops.

H. Preventing Winter Injury

Normally, vegetative growth stops about early August, and a terminal bud is set. Unusually warm fall temperatures and exces-

sive amounts of nitrogen may cause continued or renewed growth in the fall. These conditions may predispose trees to cold injury; keep trees in moderately vigorous condition before winter arrives.

1. Lethal winter injury occurs most frequently in the lower trunk, in the crown region, or in the roots near the soil surface. The tree will generally die shortly after growth begins in the spring, if the damage has been severe enough to destroy the inner bark tissue.

   Damaged inner bark is brown, while healthy bark and cambium tissue are a greenish yellow. Severe cold injury may result in split bark, however, the splits may later heal.

2. Sunscald, another type of injury, normally occurs in late winter on the south to southwest side of the main trunk and large branches. Bark, whether brown or gray, absorbs the sun's rays in midafternoon and often warms up as much as 20°F above the surrounding air temperature. As a result, bright sunny days in late winter may activate the cambium and bark tissues on southwestern trunk exposures. This reduces cold resistance and may result in injury because of extremely cold night temperatures. The bark dries, then splits, and finally wood-rotting fungi enter. This may seriously weaken or even kill the tree. The problem is most severe for young trees and smooth-bark trees such as cherry and plum.

   To protect a tree from sunscald, wrap the trunk with strips of burlap or a tree wrap material; or paint the trunk with a white indoor latex paint, which will lower bark temperature by reflecting light.

I. Cropping Problems

Biennial bearing (crop overproduction in one year and a need to rest the next year) confuses many home orchardists. This condition will alternate until finally the tree will produce fruit only every other year. To correct or reduce this problem, annual thinning done when fruit is still small will allow the tree to handle the crop and produce higher quality fruit. Thinning is done by hand when the fruit is about 1/2 inch in diameter. After thinning, the fruit should be spaced

Table 3. Why fruit trees don't bear.

Symptoms	Prevention strategy	Possible causes
Trees 4 to 8 years old have never set fruit buds or bloomed	Trees growing too vegetatively pruning especially heading cuts	Spread or tie down branches; reduce nitrogen; reduce dormant
Few fruit buds form	Trees under stress (shade, "wet feet," drought, lack of nutrients)	Choose sunny, well-drained site; fertilize and irrigate properly;
(same as above)	Trees too vegetative pruning; increase summer pruning	Reduce nitrogen; reduce dormant
Fruit buds form only at tips	Fruit buds were killed by low temperatures during bud swell	Choose site with good air drainage
Tree blooms, but all flower parts fall off when petals fall, so few or no fruit sets	Frost killed open blossoms	Choose site with good air drainage; choose late-blooming or frost-resistant cultivars
(same as above)	Flowers were not adequately cross-pollinated	When choosing cultivars, be sure to include pollenizers; during spring bloom, place flowering branches of another cultivar in buckets of water in the tree
Tree bears only every other year (e.g., biennial bearing)	Heavy crop one year weakens tree, so few fruit buds form for next year's crop	Thin fruit 4 to 6 weeks after year, bloom when crop is heavy

approximately 6 inches between fruits. Do not delay thinning. The later the thinning occurs, the smaller the fruit will be.

Additional cropping problems, their possible causes, and prevention strategies are found on Table 3.

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University of Idaho Extension

PNW 341	Choosing Pear Rootstocks for the Pacific Northwest
PNW 221	Cold Resistance of Stone Fruit Flower Buds
CIS 726	Cytospora Canker Disease in Idaho Orchards
PNW 496	Grafting and Budding Plants to Propagate, Topwork, Repair
BUL 820	Growing Apples for Local Markets in Cold Climates
CIS 866	Homeowner's Guide to Fruit Tree Fertilization
CIS 603	Insect Control for Apples and Pears in the Home Orchard
CIS 605	Insect Control for Stone Fruits in the Home Orchard
PNW 121	Nutrient Disorders in Tree Fruits
CIS 898	Pears in the Home Garden
CIS 752	Phytophthorn Collar-Rot of Orchard Trees
PNW 400	Training and Pruning Your Home Orchard
CIS 776	Why Home Fruit Trees Die

Washington State University Extension

EB1436	Apple Cultivars for Puget Sound
EB 665	Fruitfulness in Pome and Stone Fruits

To order Washington State University publications, contact your county's Cooperative Extension office or write to Bulletin Office, Cooperative Extension, Cooper Publications Building, Washington State University, Pullman, WA 99164-5912.

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Chapter 23
Small Fruits

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I. Strawberries

Strawberries are grown all over the United States and perform well throughout the Pacific Northwest.

A. Botanically, the strawberry is a member of the rose family (Rosaceae). The fruit is the swollen receptacle of the flower that bears seeds (achenes) on its surface. A high percentage of these seeds must be fertile for the berry to form properly. Plants produce for 3 to 5 years before production declines, and then they should be replaced.

1. Strawberry varieties, except for everbearing, are affected by daylength. Varieties are regionally adapted by latitude. Buy plants locally if possible, and base your purchases on regional recommendations.
2. The two main types of strawberries are June bearing and everbearing. June bearing varieties set flower buds in the fall and ripen fruit in June. Everbearing varieties have a spring and fall crop.
   a. The older cultivars of everbearers are daylength sensitive and have a break in production between the spring and fall crops.
   b. The newer day neutral varieties set the flower buds throughout the season for a very long harvest period with no production break.
   c. Total season berry production from the everbearing cultivars tends to be lower than the June bearing and day neutral types. The June bearing types produce the highest quality berries.

B. Cultivars in Idaho (in order of ripening)

1. Cultivars are June bearing in northern Idaho. Be sure to select cultivars that are adapted to northern growing conditions. For southern Idaho, select cultivars that are also adapted to high summer temperatures.
   a. Earliglow: Earliglow bears early in the season and is resistant to many diseases.
   b. Crimson King: The plants of this variety are very hardy and produce large fruit.
   c. Honeoye: Another very hardy variety with large, firm fruit.
   d. Sumas: Sumas have a high yield, but they are susceptible to fruit rot. They grow large fruit.
   e. Totem: These fruits are good fresh and frozen. Totems are disease resistant.
   f. Benton: This variety grows a medium-sized fruit with a light inside color.
   g. Shuksan: Shuksans are susceptible to virus. The fruit is excellent fresh and frozen.
   h. Sparkle: This variety produces a soft fruit with an excellent flavor.
2. Everbearing—Day neutral
   a. Fort Laramie: An everbearing plant, the Fort Laramie is very hardy and productive.
   b. Quinault: Another everbearing plant, the Quinault produces small berries, which are soft and have a good flavor.

c. Tristar: The Tristar is day neutral and productive; it bears relatively large fruit with a good flavor.

d. Tribute: A variety that is superior to Quinault, day neutral, and later in the season than Tristar, the Tribute has a firm fruit.

C. Culture

1. Planting

a. Well-drained soil is required. Heavier soils should be molded to raised beds for improved drainage. Strawberry pyramids and containers work well and give good yields in small spaces. Incorporation of organic matter benefits both light (sandy) and heavy clay soils. Adjust pH to 5.5 to 6.5.

b. Established weeds: Gardeners must eradicate all perennial weeds before planting. Use repeated fallow cultivation or heavy mulches.

c. Matted row culture: Most popular in home gardens. Set plants 1 1/2 to 2 feet apart in rows 3 to 4 feet apart. Runners from initial planting are allowed to fill in to form a solid planting, until it reaches approximately one plant every 5 to 8 inches. Remove excess plants or runners. Plants at a higher density will produce fewer and lower quality berries.

d. Hill culture: Plants remain as individual plants in the garden; remove all runners. Space individual plants 15 to 18 inches apart, and place them in rows 2 1/2 to 3 feet apart.

2. Setting plants

a. Plant in early spring or early fall. In areas where frost heaving is a problem, plant only in spring, or mulch fall plantings to reduce heaving. If you plant at any time other than early spring, irrigation is important. Plants are mostly available in stores in the spring.

b. Use certified virus, disease, and insect-free stock when establishing a new planting to ensure that pests are not introduced into the garden with planting stock.

3. Fertilization

a. Timing

i. It is important to fertilize and water June bearers in late summer to promote maximum fall growth and flower bud formation.

ii. Spring fertilization results in excessive formation of leaves and runners and in less fruit growth.

iii. Fertilize everbearers and day neutrals with small amounts several times during the growing season.

b. Amount

i. Apply a total of 30 to 60 pounds of actual nitrogen per acre for all types of strawberries.

ii. June bearing types should be fertilized in early August, if irrigation is available; otherwise, fertilize in mid-September without irrigation.

iii. A balanced fertilizer such as 10-10-10 will supply ample phosphorus and potassium. Any deficiencies should be diagnosed with a soil or plant tissue test.

4. Irrigation—Consistent watering is essential when plants are first set and during dry periods in spring and summer. Irrigate in the morning to reduce rot.

a. Critical irrigation periods: These occur during harvest or in late August and fall, when plant growth resumes and the flower buds form for the following year's crop.

b. Efficient irrigation methods: Black plastic or straw mulch and plastic-tube drip irrigation systems (soakers) are highly adaptable to strawberry culture and water conservation. Strawberries absorb 90 percent of their water from the top foot of soil.

5. Renewal (June bearers only)—After the harvest early in July, June bearers will benefit from removal of the foliage, which will allow you to rid the plants of disease-infested foliage and will act as a stimulant to the plant for new, vigorous foliage.

a. Cut the foliage with a lawnmower set high or use hand tools. Be careful not to damage the crowns.

b. Rake leaves from the plot.

6. Cold protection

a. Winter protection: In colder areas, strawberries will benefit from a mulch. Coarse hay or straw may be placed over the entire planting when the ground begins to freeze. The mulch should be removed from the plants in the spring. Weed-free mulch materials should be used.

b. Spring frosts: These often kill the early flowers. Sprinkle plants with water during the coldest frosts (when temperature at ground level reaches 34°F). Leave the water running until the temperature is above 32°F, or cover plants with a light mulch or a floating row protective fabric.

D. Common Plant Problems—Diagnosis and Control

1. Diseases

a. Verticillium wilt

i. Symptoms: A soilborne fungi, verticillium wilt causes wilting and death of older leaves in individual plants or groups of plants. Black lesions develop on petioles. New roots may be short with blackened tips. Plants may outgrow these symptoms.

ii. Control: Avoid planting strawberries in ground where potatoes, tomatoes, strawberries, or other susceptible crops have been planted. Eliminate infected plants and do not replant in spots. Rotate crops.

b. Red Stele: Soilborne fungi

i. Symptoms: Often there are no symptoms the year of planting. During the first year of fruiting, there may be dwarfing, reddening of leaves, and wilting of older leaves. Root tips may decay, causing "rat-tailed" appearance. The central core or vascular system of root (stele), may be clogged by fungi and show a red discoloration of the stele. Symptoms are most readily apparent early in the season. They may be difficult to see later in the season. Not all the roots of an infected plant will show symptoms.

ii. Control: Use certified plants. Plant in disease-free soil. The soil needs to have good drainage. Earliglow, Sparkle, Tribute, Tristar, and Totem are resistant to this disease.

c. Viral diseases

i. Symptoms: Viral diseases can cause stunting, an unevenness in field or planting, as well as some foliar symptoms, such as streaking, cupping, and yellowing.

ii. Control: Use certified planting stock. Control the aphid infestation, as aphids are the primary vector of disease.

d. Fruit rot/botrytis

i. Symptoms: Botrytis is evident in a gray, fuzzy mold on fruit during moist weather. Infections start at bloom. Fruit from the infected blossom rots as it ripens.

ii. Control: Ensure good air circulation, remove infected fruit, and clean straw mulch so that fruit rests on clean, dry surface. Use fungicide during wet springs. Apply fungicide at 10 percent bloom. Repeat according to label directions.

e. Common leaf spot

i. Symptoms: Leaf spot causes foliage with dark red or purple spots, that gradually becomes gray-white with age. Fully developed spots are 1/8 inch in diameter and have a whitish center with red margin. Infection occurs during moist weather and is most severe during spring and fall. Crimson King is resistant.

ii. Control: Fruit rot fungicide sprays will keep this disease under control. Removing foliage from June

bearers after harvest reduces inoculum.

f. Powdery mildew
   i. Symptoms: Disease causes upward curling of leaflet edges. Leaf undersides become reddened and coated with a grayish white fungus. Leaves later turn purplish red. Totem and Benton strains are very tolerant. Shuksan has moderate susceptibility. Fort Laramie is very susceptible.
   ii. Control: Destroy old infected leaves.

2. Insects
   a. Root weevils
      i. Damage: Larvae feed on root systems. Adults notch edges of leaves.
      ii. Control: Don't use chemical control in the home garden. Collect adults at night on leaves and destroy.
   b. Aphids
      i. Damage: Can spread viruses.
      ii. Control: Hose off and use insecticidal soap sprays.
   c. Spider mites
      i. Damage: There is a stippled appearance to top part of leaves, which leads to bleaching. Webbing and mites will be found on the undersides of leaves.
      ii. Control: See aphid control.
   d. Spittle bugs are small, yellow-green insects similar to the leaf hopper in appearance.
      i. Damage: Nymphs develop "spittle" on plants.
      ii. Control: Since this pest is not a major one, there is no need to control.
   e. Slugs (mostly nocturnal): Many sizes feed on foliage and fruit.
      i. Damage: Slugs cause leaf damage, often in the leaf center.
      ii. Control: Manually remove or use slug bait around the perimeter of the garden. Bury containers of beer with the lip of the container at soil level to attract and drown slugs. Check containers often.

II. Red Raspberries

Red raspberries are grown as a commercial crop in the Pacific Northwest. More than 10,000 acres are planted in Washington, Oregon, and British Columbia. Raspberries can be expected to do well in most Idaho locations, although severe freeze injury to canes will occur in many winters in southeastern Idaho.

A. Botanically, raspberries are members of the Rose family (Rosaceae) and belong to the genus Rubus, as do blackberries and other caneberries. The plants are perennial, with roots that live 40 years or more. Red raspberries have stiff erect canes, which are usually covered with thorns. Canes are produced freely from adventitious buds on the roots, and they generally live two seasons.
   1. Fruit is borne on lateral fruit spurs produced on 1-year-old canes. Fruiting canes die after harvest; meanwhile, new canes (primocanes) have been growing from the root system to be next year's fruiting wood.
   2. The raspberry is an aggregate composed of 75 to 125 drupelets that separate from the receptacle when ripe, producing a hollow "berry."
   3. Optimum production for red raspberries is in areas with relatively cool summers, a rain-free harvest season, and a mild winter with sufficient cold to satisfy chilling requirements. However, care in cultivar selection will sustain fruit in areas lacking in one or more of these conditions. Raspberries are one of the hardiest of cane fruits. Some cultivars will tolerate temperatures to -20°F without damage.
   4. Red raspberries come in two types: Summer bearing and fall bearing.
      a. Summer bearing raspberry canes are biennial, growing one year and producing the next.
      b. The fall bearing raspberry produces canes that bear on the upper part of the

primocanes in the same growing season. These canes, if left the second year, will bear fruit on the lower portions.

i. Alternatively, the canes can be totally removed by mowing to the ground after the fall crop is harvested. When managed in this way, fall bearing raspberries will bear only the single crop in the fall.

ii. In Idaho locations with short growing seasons, fall bearing raspberries may not ripen their crop. Trial plantings of these cultivars are recommended to ascertain their ripening characteristics.

B. Cultivars in Idaho

1. Summer bearing

a. Boyne: Hardy in cold conditions, Boynes are good fresh and frozen. This variety is productive.

b. Canby: Canbys produce a thornless plant. They are virus resistant and aphid immune, but sensitive to root rot. This variety is very productive, and it is cold hardy through Zone 4.

c. Haida: Though this variety is hardy and has large, sweet, firm berries, it has short canes and is low in vigor.

d. Latham: A popular variety, Lathams are hardy and have a nice flavor.

e. Newburgh: Newburghs are cold hardy, as well as resistant to root rot and mosaic virus.

f. Nootka: This variety is a firm, flavorful, vigorous plant.

g. Nordic: Nordics are cold hardy, productive, and resistant to fungal diseases and aphid feeding.

h. Skeena: A large, bright fruit, the Skeena is hardy and root rot susceptible.

i. Taylor: A long conic fruit, the Taylor has an excellent flavor and is productive.

j. Titan: The Titan produces a hardy, large fruit with a mild flavor. It is very productive and root rot susceptible.

2. Fall bearing

a. Amity: This variety harvests about a week earlier than Heritage. It has a good size, flavor, and firmness.

b. Autumn Bliss: A early crop variety, Autumn Bliss creates berries that have a large size and good flavor.

c. Heritage: The Heritage ripens late in fall and produces heavy yields.

d. Redwing: A soft fruit, resistant to high temperatures, this strain ripens earlier than Heritage.

e. Ruby: Ruby bears a productive, large fruit, which can produce when planted with Amity.

f. Summit: While this plant has a better flavor than Heritage and is root rot resistant, it produces a small fruit.

C. Culture

1. Planting—Plant in raised mounds or beds in heavier soil to improve drainage away from the crown of the plant.

a. Use certified stock, plants, or root cuttings.

b. Spacing is generally 1 1/2 to 3 feet apart in rows 6 to 8 feet apart. You must ensure a recommended 4 foot minimum depth to winter water table to create optimum conditions for high fertility and freedom from erosion.

c. Soil: Good drainage, high water-holding capacity, and adequate depth are essential. Plants are highly susceptible to root rot. Heavy, poorly drained soil severely limits life expectancy of plants. Irrigation is required on sandy or gravelly soils.

2. Established weeds—Gardeners must eradicate all perennial weeds before planting. Use fallow cultivation or heavy mulch.

3. Training—Place top wires at 4 1/2 to 5 1/2 feet to support canes. You may also have another wire at 2 to 3 feet. Use one-, two-, or four-wire systems. Plants will be shorter in some climates (Fig. 1).

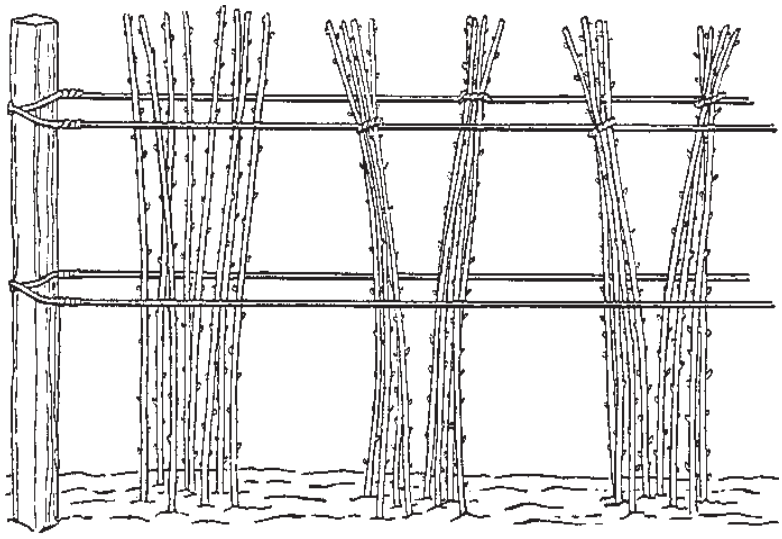
4. Hill culture—Maintain plants as individual hills (weeding is easier), or allow to fill in as a solid row. Light distribution

is better when each individual cane is spaced along the wire separately. Canes are bundled commercially for labor savings. Tie canes to top wire in fall or winter as in Fig. 1. Tie in clumps or individually along the wire.

5. Pruning—Top dormant canes 6 to 10 inches above the wire in early spring to stimulate lateral branching. Canes are subject to dieback in a cold winter if they are pruned in the fall.
   a. Remove all fruiting canes after harvest, as that reduces insect and disease problems, helps in hardening off process, and simplifies weed control. Remove weak new canes or those with small diameter.
   b. Cut off canes close to soil line. Leave all canes over 6 feet and the diameter of your index finger (about 12 healthy canes per hill, or in solid rows spaced 4 to 5 inches between canes). Keep rows no more than about 12 inches wide.
6. Fertilization—Test the soil to determine plant needs. Broadcast apply in spring over rows or split application with one-half applied at first growth in spring and the remaining one-half at the beginning of or at fruit set. Apply a total of about 30 pounds actual nitrogen per acre.
7. Weed control—Hand hoe weeds between hills. Cultivate very shallowly.
   a. Remove suckers between rows as they emerge.
   b. Cover crops between rows are effective.
   c. Herbicides can be used to control weeds. Make sure they are registered for use in raspberries.
8. Irrigation—Watering frequency will vary with conditions. As a general rule, irrigate every 2 to 3 weeks before and after harvest; then supplement with a weekly irrigation during harvest.
9. Cold protection
   a. Winter protection: Good snow cover or mulch will protect crowns. In severe areas, or with less hardy cultivars, pin canes to the ground and mulch over them.
   b. Spring frosts: See strawberries.

D. Common Plant Problems—Diagnosis and Control
   1. Diseases
      a. Phytophthora root rots: A fungus disease caused by *Phytophthora erythroseptica*.
         i. Symptoms: The disease kills the fine feeder roots, while the interior of any larger roots becomes brown. Suckering is reduced. New primocanes wilt and leaves die. Floricane leaves turn bright yellow and brown and then die out. Favored by wet, heavy soils.
         ii. Control: Use certified plants free of disease. Plant on well-drained soils. Increase drainage by using raised beds.
      b. Virus diseases
         i. Symptoms: Viruses create stunting, or delayed growth in the spring; crumbly berries; ring spotting; and a bright yellow mosaic on the leaves.
         ii. Control: Plant certified stock; remove infected plants.

Fig. 1. Mature raspberry canes after spring pruning and tying to four-wire trellis.



A Hill after spring heading. B Hills with canes spread and tied. C

c. Crown gall: Bacterial disease.
    i. Symptoms: Dark "knobs or tumors" of growth appear at or below soil line. Crown gall spreads primarily by pruning, when it enters new wounds on pruning shears. It also can come in on infected planting stock.
    ii. Control: Remove plants.
d. Fruit rot/botrytis (see strawberries)
e. Spur blight: A common fungal disease (*Didymella applanta*) in damper areas, spur blight causes little damage in this area. Buds on infected canes are more susceptible to winter injury.
    i. Symptoms: Spur blight creates wedge-shaped necrotic lesions on leaves, especially near base of cane. Infected leaves drop, leaving petiole attached to cane. Brown or reddish-brown lesions appear around buds at base of petiole; these lesions are usually limited to one or two buds. Minute black fruiting bodies appear on lesion by fall.
    ii. Control: Avoid overhead watering if possible. Remove and destroy infected canes. Thin canes appropriately to allow for air movement. Avoid excessive nitrogen fertilizer.
f. Verticillium wilt (see strawberries)
g. Anthracnose (see blackberries)
h. Yellow rust: Caused by a fungus, particularly following late spring rains.
    i. Symptoms: Plants develop leaves with yellow spotting, and later become dusty from the yellow spores. Lower leaves yellow and drop, and the crop is reduced. The fruit dies before maturing. In the winter, infected leaves produce black spores at sites of infection.
    ii. Control: Good sanitation. Remove sources of infection; cut old fruiting canes immediately after harvest and destroy.

2. Insects
    a. Crown borer
        i. Damage: These insects bore tunnels in lower portions of canes, which cause the death of the cane.
        ii. Control: Dig out infected plants by hand. Replant any new plantings in different area.
    b. Spider mites
        i. Damage: Their feeding reduces plant vigor and causes leaves to brown and drop prematurely. When pesticide use kills natural predators, the mites are often a problem.
    c. Cane borer
        i. Damage: These insects bore tunnels in the upper portions of the cane (Shepherd's Crook).
        ii. Control: Prune out any affected cane and destroy. Use no chemical control.
    d. Yellow jackets
        i. Damage: Yellow jackets hide in ripe fruit and feed on sugars. They are a hazard to those working in the plants.
        ii. Control: Keep overripe fruit harvested. Yellow jacket traps can be effective.
3. Other
    a. Crumbly berry
        i. Damage: Crumbly berries may reveal a plant with a Boron deficiency. Soil testing is recommended. A virus disease may interfere with flower functions, causing crumbly fruit. Poor pollination occurring from lack of bees or from poor weather during flowering also causes crumbly fruits.
        ii. Control: Add boron, if necessary; add bees to the field; and replace plants with virus free stock.
    b. Sunburn/high temperatures
        i. Damage: The fruit forms, but it doesn't ripen, or it ripens slowly. This problem is caused by excess ultraviolet rays or elevated temperatures.
        ii. Control: Shade the plants, especially during high noon hours. Use shadecloth or plant in the shade of other foliage or structures.

III. Black and Purple Raspberries

A. Purple raspberries are hybrids of red and black. The fruits resemble the red more than the black. Both have canes that will root at the tips and are propagated by tip layers.
   1. Black raspberries are less cold hardy than red or purple types. Freeze injury will begin at temperatures around -5°F.
   2. They are susceptible to virus diseases and anthracnose.
   3. Except for Royalty, the following cultivars sucker poorly, so hill culture rather than hedgerow is recommended.

B. Cultivars in Idaho
   1. Black raspberries
      a. Allen: An early fruit with a concentrated ripening, this strain is hardy.
      b. Black Hawk: A late variety, Black Hawk produces large, flavorful berries. A productive variety, it is very hardy, to Zone 5 (-20° to -10°F).
      c. Lowden: The Lowden is a cross between a purple and a black raspberry with an excellent flavor. The plant has good disease resistance and is hardy.
      d. Munger: The fruit of the Munger has an excellent flavor. Mungers ripen in midseason and are also hardy.
   2. Purple raspberries
      a. Brandywine: A variety that produces large fruit with a tart flavor, the Brandywine is very winter hardy, to Zone 4 (-30° to -20°F).
      b. Royalty: Royalty produces large fruit, which is sweet when fully ripe. It is a very productive variety and hardy to Zone 4 (-30° to -20°F). This variety ripens late.

C. Culture (see Red Raspberries)

D. Common Plant Problems—Diagnosis and Control (see Red Raspberries)

IV. Trailing Berries (Blackberries)

Trailing berries are in the same genus as raspberries (*Rubus*). Their fruit is similar to raspberries, but a white core or receptacle remains part of the fruit when picked.

A. Blackberries are the least hardy of the berries grown in Idaho. These plants can be injured by temperatures between +5° and -10°F. Boysenberries, Loganberries, Tayberries, Nectarberries, and Marionberries are all trailing berries.

B. Cultivars In Idaho
   1. Cherokee—The plant has an upright, thorny, strong vigorous growth; it is hardy to Zone 5 (-20° to -10°F).
   2. Chester—This variety has a semi-erect plant that is productive and hardy to Zone 5 (-20° to -10°F). In fact, the Chester is the most hardy of the thornless type. It produces large fruit late in the season.
   3. Darrow—A tall, semi-erect, variety, the Darrow is the most cold hardy cultivated blackberry.
   4. Hull—Another semi-erect variety, the Hull produces large fruit. The plant is thornless, and its growth is vigorous.
   5. Roseborough—An upright plant, the Roseborough holds up under extreme heat and dryness. It produces heavy crops and is hardy to Zone 5 (-20° to -10°F).

C. Culture
   1. The planting, fertilization, and soil requirements are similar to those for red raspberries.
   2. Trellising systems—Long canes of trailing and semi-erect varieties are generally "woven" on a two-wire trellis system as in Fig. 2. Wires are 18 inches apart with the top wire 5 feet from ground level. Upright cultivars will not require trellising, or at most a single wire at 5 feet.
   3. Pruning—Remove fruiting canes after harvest. Weave new canes around top wire in fall or spring.

D. Common Plant Problems—Diagnosis and Control
   1. Diseases (see red raspberries)
      a. Leaf and cane spot (Septoria leaf spot): Fungal disease.
         i. Symptoms: Leaf spots vary from light to dark brown. They begin as an 1/8 inch purple spot later turning brown. Cane spots are larger and may contain fruiting bodies

(spores). Spots girdle and kill cane. The disease is promoted by canes overwintering on or near ground.

ii. Control: Remove fruiting canes after harvest. Provide good air circulation.

b. Anthracnose: Overwinters on infected canes.

i. Symptoms: Purple spots appear on canes, then increase in size, and develop light gray centers with brown-purple edges. Spots converge to form large irregular lesions. Canes may dry and crack. On leaves purple spots enlarge to form gray to white areas that drop out. Berries ripen prematurely and are small and dry.

ii. Control: Remove canes after harvest. Leave no old stubs. Thin to allow air circulation.

2. Insects (see red raspberries)

V. Blueberries

Blueberries, members of the Ericaceae or heath family, prefer a culture similar to rhododendrons or azaleas. Wild blueberries are often called "huckleberries," but are just different species of the cultivated blueberry.

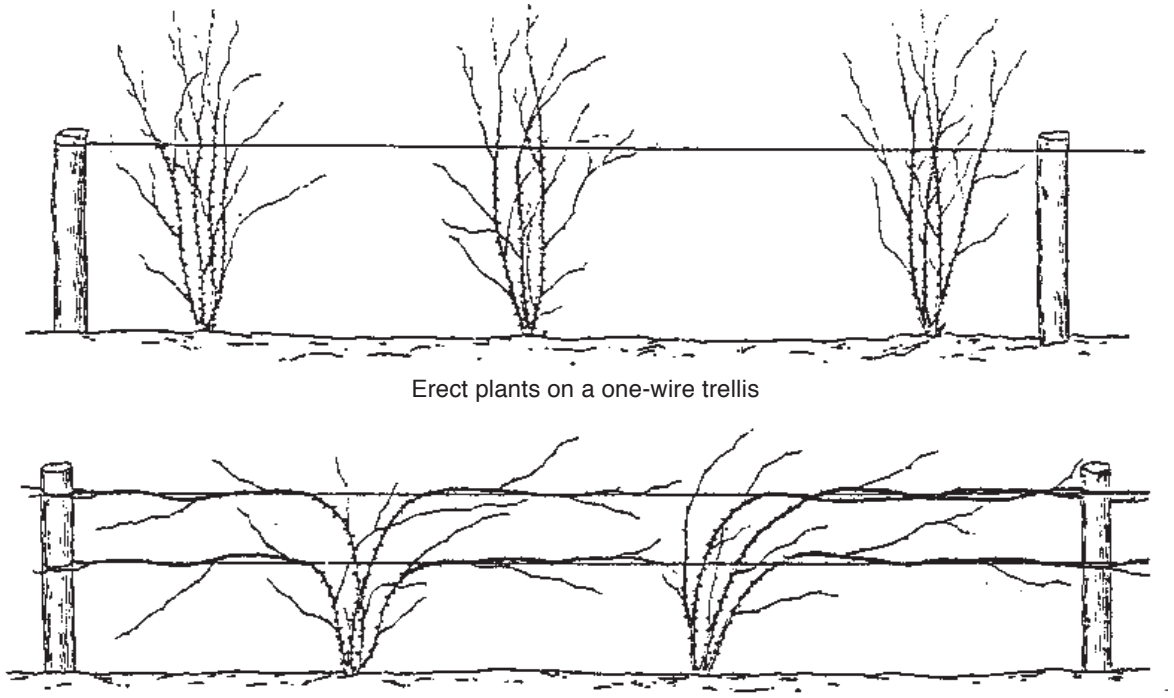
A. Blueberry production in Idaho will be limited to those sites with acidic soil (pH of 4.5 to 5.5).

1. In areas with alkaline soil, grow blueberries in raised beds or large containers with peat. The addition of ground sulfur, 1 pound per 100 square feet in sandy soil and 2 pounds per 100 square feet in clay soil, will lower the pH approximately one point.
2. Blueberry plants are attractive and can serve as ornamentals and fruit producers, as they tolerate partial shading better than other berry crops.
3. Blueberries are self fertile but will have higher yields with cross-pollination. The plants are hardy.

B. Cultivars in Idaho (listed in order of ripening dates).

1. Earliblue—This short plant variety flowers very early.
2. Patriot—The Patriot is a very hardy plant with large, firm fruit.
3. Northland—A hardy, spreading plant, the Northland has a good flavor.

Fig. 2. Trellises for blackberries.



Erect plants on a one-wire trellis

Trailing plants on a two-wire trellis.

4. Bluecrop—A fruit with an excellent sweet flavor, this variety has a vigorous plant.
5. Blueray—Large, firm fruit.
6. Jersey—Fair flavor; late, vigorous plant.

C. Culture
1. Established weeds—Eradicate all perennial weeds before planting. Use fallow cultivation or mulches.
2. Planting
   a. Setting: Blueberries are set out as dormant plants in late winter or potted plants in spring or fall.
   b. Soil: The root system is shallow, fibrous, and prefers soil with high organic matter and good water holding capacity. Add organic matter to soil when planting; mix well with soil in and around planting hole. Mulch to protect the shallow root system from temperature extremes and drying.
3. Pruning—Prune hard after planting to stimulate new growth. For mature plants, remove older canes to ground or to strong lateral, retaining 1- to 3-year-old wood.
4. Fertilization—The amount of fertilizer used depends on the rate of previous growth. Apply light amounts three times in the growing season for optimal growth. Ammonium sulfate is a good nitrogen source to help acidify soil.
5. Irrigation—Keep soil evenly moist. Plants need adequate drainage. Drip irrigation systems work well. Mulch up to 6 inches deep to conserve water.

D. Common Plant Problems—Diagnosis and Control
1. Diseases
   a. Mummy berry: Fungus disease (*Monilinia vacciniicorymbosi*).
      i. Symptoms: Infected berries are reddish-buff or tan "mummies." They fall to the ground, gray, shriveled, and hard to overwinter. In spring as blueberry buds break, fruiting cups grow from mummies on the soil and release infecting spores. Blossoms become infected and turn brown and wither. New vegetative shoot is blackened in the center and wilts and dies. The remaining fruit becomes infected.
      ii. Control: Remove and destroy all infected parts including fruit. Mulch thickly to bury any dropped mummies. In early spring destroy developing fruiting cups by cultivation. Apply fungicide during bloom according to label instructions.
   b. Botrytis
      i. Symptoms: Twig dieback in wet weather, invading blossoms, and moving down shoots.
      ii. Control: Apply fungicide early in spring when growth begins. Repeat, but do not make more than four applications before harvest. Follow label instructions. Prune out and destroy dead twigs.
2. Insects
   a. Aphids
      i. Damage: Deform leaves, devitalize plants, secrete honeydew.
      ii. Control: Light infestations may be controlled by natural insect predators; use insecticidal soap.
   b. Cherry fruitworm
      i. Damage: Larvae approximately 3/8 inch in size will bore into the berries.
      ii. Control: Insecticidal sprays before bloom or after, according to label directions, for cherry fruitworm on blueberries.
   c. Leafrollers
      i. Damage: Create webs and feed on foliage and fruit.
      ii. Control: *Bacillus thuringensis* at any time.
   d. Scale
      i. Damage: Weaken plant.
      ii. Control: Prune off infested areas as soon as observed.
3. Birds—Can be a persistent problem. Net plants as the fruit colors. Secure the perimeter of the net carefully. Use mylar strips or balloons to scare away birds.

VI. Hardy Kiwi

A. The botanical name of the hardy kiwi fruit, also known as Siberian Gooseberry, is *Actinidia arguta*. It is a member of the Actinidiaceae family (not related to the common garden gooseberries). Kiwi fruit is native to eastern Asia. Chinese gooseberry (*A. chinensis*) is not hardy anywhere in Idaho, as fruit buds are damaged by temperatures of 10° to 15°F.

1. The fruit is fuzzy and brown skinned, approximately the size of a large cherry. The flesh is green with edible black seeds and has a unique "fruity" flavor. Fruit is high in vitamin C and stores well.
2. Kiwi is dioecious (Latin for two houses), which means there are separate male and female plants. One male will pollinate six to eight female plants within 50 feet. Bloom periods between male and female must match. Some varieties are self-fertile.

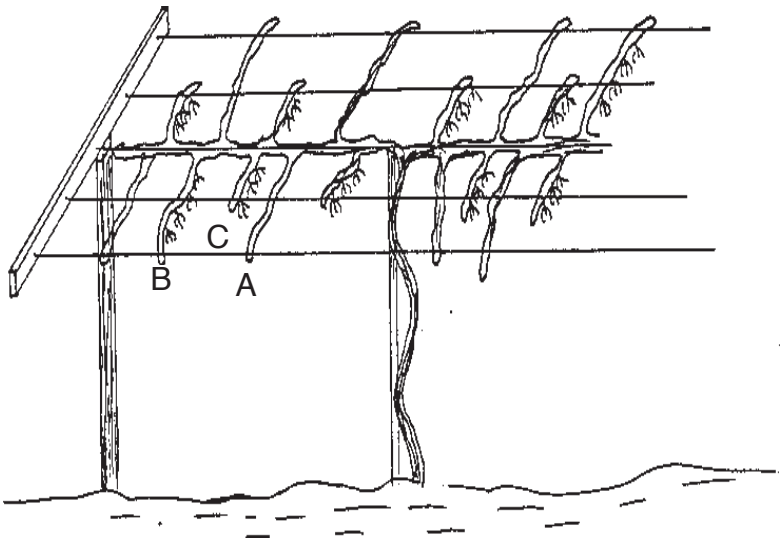
B. Cultivars in Idaho

1. Seedlings—Many varieties are just listed as *A. arguta*, available in male or female plants.
2. Ananasnaja—A variety with a fuzzless skin, the Ananasnaja is very sweet and spicy. The Russian name means "pineapple-like."
3. Issai—Self-fertile, the Issai has fruit with sweet flesh, often used as a fruit-producing pollinator. This variety is very productive.
4. Meader—A good pollinator for Ananasnaja, the Meader produces sweet fruit and ripens in late August.

C. Culture

1. Site
   a. Hardiness: Dormant vines are hardy to -25° to -30°F and sensitive to late spring frosts. Avoid frost pockets.
   b. Soil: Kiwi need well-drained soil, even soil moisture, and a sunny location **free from wind** to protect fruit and laterals from damage and drying.

Fig. 3. Kiwi on trellis.



2. Training and trellising—The vines are large and heavy so the kiwi needs a strong trellis system as in Fig. 3. The Kiwi is a perennial with a lifespan of 50 to 60 years. Pressure-treated posts should be 5 to 6 feet tall with another 3 feet below ground. Use high tensile 12 or 10 gauge wire. A T-bar trellis with three to five horizontal wires is recommended. Space the plants 10 to 15 feet apart in row and 10 to 15 feet between rows.
3. Pruning
   a. Summer pruning: A must for kiwis. Avoid shading of fruiting wood. Prune new growth several times to 6 to 8 inches during the growing period.
   b. Winter pruning: Prune during the dormant period. Start by developing well defined leaders or cordons which will be permanent. Set up an evenly spaced system of fruiting arms or laterals.
      i. Remove fruiting wood that is losing vigor. Start with one-third removal each year.
      ii. Remove fruiting lateral after third year.
      iii. Shorten 1-year wood to two to four buds. Allow second-year wood to fruit freely.

4. Fertilization
    a. Young plants: Add balanced fertilizer split into two applications.
    b. Mature plants: Apply one-half to two-thirds of the balanced fertilizer at bud break; then apply the rest after the fruit is set.
5. Harvesting—Plants take 3 to 4 years to bear; they reach full production in 7 to 8 years. Pick the fruit in late August to November when it is **firm-ripe** (for best storage ability). Keep refrigerated.

D. Common Plant Problems—Diagnosis and Control
1. Diseases—None.
2. Insects—None.

VII. Black Currants

A. The black currant, or *Ribes nigrum*, is a native of central and eastern Europe.
1. The native plant grows in damp, woodsy places. A fully grown bush may reach 5 to 6 feet in height and spread, and have an average yield of 10 to 12 pounds per plant.
2. There are many cultivars, mostly of European origin. Most are extremely hardy. Black currants are partially self-fruitful, but set a larger drop with another cultivar nearby. Plant nonblister rust resistant cultivars at least 1,000 feet and preferably 3/4 mile from the nearest five-needle pine.

B. Cultivars in Idaho
1. Black September—This variety produces a large, firm fruit with a strong black currant flavor that is hardy to -30°F. The plant is mildew resistant.
2. Consort—The fruit of the Consort has a sweet, musky flavor, while the plant is self-fruitful, resistant to white-pine blister rust, and hardy to -30°F.
3. Crusader—The Crusader needs a pollinator; it is rust resistant.
4. Jostaberry—This variety is a cross between a black currant and a gooseberry. It produces large fruit that is good fresh. The vigorous plant is resistant to mildew and white-pine blister rust and is cold hardy.

C. Culture
1. Soil—The currant will grow on a wide variety of soils. The ideal pH is 6.5 with good water holding capacity. Currants will tolerate poorly drained soils. Add organic matter to light soils.
2. Site—Plants bloom early so avoid frost pockets. Though the currant prefers a sunny location, it will tolerate partial shade. Control all perennial weeds before planting.
3. Planting—Plant in late winter or early spring. Space the plants 5 feet apart in rows, with 6 feet between rows. Plants grow by stooling; plant 2 inches deeper than in nursery. Cut all shoots to 2-inch stubs at planting. Plants root easily; use prunings as cuttings.
4. Pruning—Prune annually, as black currants bear best on 1-year wood. Remove all 3-year-old wood annually, as well as any older growth. Cut to strong young shoot, or near base, or off completely. Keep five or six canes each of 1- and 2-year-old wood.
5. Irrigation and fertilization—The currant likes even soil moisture. It will require frequent irrigation in arid parts of the state. Currants are fairly heavy feeders, so apply balanced fertilizer in March and more nitrogen in April.
6. Weed control—These plants are shallow rooted, so avoid deep cultivation. Sawdust mulch 4 inches thick is effective in controlling weeds.

D. Common Plant Problems—Diagnosis and Control (see Gooseberries)

VIII. Red and White Currants

A. Red currants, or *Ribes rubrum* and *Ribes spicatum*, are native to Europe. A full-grown bush may be 5 to 6 feet in height and spread. The fruit is smooth skinned and glistening. Red currants are used for jelly, pies, juice, and wine.
1. The white currant is a sport of the red currant, and the culture is the same.
2. The plants are self-pollinating; the average yield of the mature plant is 8 to 10 pounds of fruit per plant.

B. Cultivars in Idaho
   1. Red currants
      a. Cherry: This variety has a high fruit quality, is hardy in Zone 3 (-40° to -30°F), and is productive.
      b. Minnesota 71: A vigorous plant, the Minnesota 71 produces large fruit of good quality.
      c. Red Lake: The Red Lake is productive with a long growing season. It produces early fruit. The dark red berries are widely grown.
   2. White currants
      a. White Imperial: An old, but vigorous variety, the White Imperial produces very sweet medium to large fruit.
      b. White Pearl: The White Pearl has a pale yellow skin and large fruit.

C. Culture
   1. Soil—Both white and red currants are less tolerant of poorly-drained soils than black currants. Ideal pH is 6.5. The plants need good water holding capacity; add organic matter to light soils.
   2. Site—These plants bloom early, so avoid frost pockets. The flowers are hardier than black currants; you'll find them useful for north-facing walls. If you want full flavor in the fruit, then these plants require a sunny location. Control all perennial weeds before planting.
   3. Planting—Plant in late winter or early spring. Space plants 5 feet apart in rows, with 5 feet between rows. Plant at the same depth as in nursery.
   4. Pruning—Your objective is to create a goblet-shaped bush with 8 to 10 main branches. Prune leaders to outward facing-buds. Prune drooping branches to upward-facing buds. Fruit buds produced in clusters at base of 1-year wood or on short spurs on old wood. Maintain about three canes each of 1-, 2-, and 3-year-old wood.
   5. Irrigation and fertilization—These currants like even soil moisture. Use mulch on light soils. The plants are fairly heavy feeders, so apply balanced fertilizer in March at bud break.
   6. Weed control—As the plants are shallow rooted, avoid deep cultivation.
   7. Harvesting—Pick as soon as the berries are clear in color. Pick whole clusters to avoid injury to delicate fruit.

D. Common Plant Problems—Diagnosis and Control (see Gooseberries)

IX. Gooseberries

A. Botanically, gooseberries are known as *Ribes usa-crispa*.
   1. They are self-pollinating and are a deciduous, thorny shrub.
   2. The mature plant has a height and spread of 5 feet, and produces 5 to 6 pounds of fruit. It bears fruit like red currant at the base of 1-year wood and on spurs of older wood.
   3. Gooseberries are more tolerant of hot weather than currants.

B. Cultivars in Idaho
   1. Captivator—This variety is winter hardy and disease resistant. It produces a large 1-inch fruit that is pink to red when it is ripe and has an average flavor.
   2. Pixwell—A hardy, thornless plant, the Pixwell produces fruit with sweet, pink flesh.
   3. Poorman—A vigorous productive variety, the Poorman has a highly flavored, wine-red fruit. The plants are hardy.
   4. Welcome—Welcomes are extremely productive plants with medium to large, light-green fruits that have a sweet-tart flavor.

C. Culture
   1. Soil—The top 18 inches of soil needs to be well drained. An ideal pH is 6.5. Gooseberries need good water holding capacity; add organic matter to light soils.
   2. Site—Avoid frost pockets, as the plants bloom early and blossoms can be damaged by spring frost. Gooseberries are tolerant of partial shade, though they do best in sunny site. Control all perennial weeds before planting; the thorny plant is hard to weed around.

3. Planting—Plant in late winter or early spring. Gooseberries are one of the first berry plants to leaf out. Space plants 5 feet apart in rows, with 5 feet between rows. Plant at same depth as nursery.
4. Pruning—See red currants.
5. Irrigation and fertilization—The gooseberry likes even soil moisture. Uneven or heavy watering may cause fruit to split as it ripens. Use mulch on light soils. The plants are fairly heavy feeders so apply balanced fertilizer in March at bud break.
6. Weed control—As the plants are shallow rooted, avoid deep cultivation.
7. Harvesting—Protect the plants from birds with netting. Pick as soon as the berries are good size, but while they are still green (June or July). For dessert fruit thin every other one. Use thinnings for cooking.

D. Common Plant Problems—Diagnosis and Control
   1. Diseases
      a. Anthracnose or leaf fungal disease: Overwinters on dead leaves.
         i. Symptoms: The disease creates small leaf and fruit spots. By midseason there is a yellowing and dropping of leaves.
         ii. Control: Remove and destroy affected leaves. Prune to open center to allow air circulation.
      b. Powdery mildew: A fungal disease that overwinters on twigs.
         i. Symptoms: The mildew can be seen as a white, powdery growth on the surface of leaves, green shoots, and fruits. Infected plants are stunted.
         ii. Control: Prune to maintain an open plant with good air circulation.
      c. White pine blister rust (fungal disease): It is no longer illegal to cultivate *Ribes* in Idaho. (Too many wild *Ribes* combined with rust resistant pine cultivars). Alternate the host to five-needle pines. Black currant is most susceptible.
         i. Symptoms: Small cuplike spots appear on the underside of leaves and produce orange yellow spores.
         ii. Control: Remove and destroy infected plants. Do not plant Ribes near five-needle pines.
   2. Insects
      a. Currant fruit fly (gooseberry maggot).
         i. Damage: The larvae enter the soil in late June. They overwinter as pupae in brown cases the size of wheat grains. Flies emerge in April and lay eggs on the developing berries of either currants or gooseberries.
         ii. Control: Use shallow cultivation under bushes during July and August , as this method helps expose and kill pupae.
      b. Currant aphid
         i. Damage: A small, yellow aphid appears on new growth in the spring. The aphid overwinters as eggs on bark. It causes cupping and red color on new leaves. Honeydew accumulates.
         ii. Control: Use water washes or insecticidal soap.
      c. Currant borer
         i. Damage: The adults are clear winged with blue-black coloring and yellow markings. The larvae tunnel in the canes. Canes wilt in summer and autumn.
         ii. Control: Prune out and destroy infected canes.
      d. Imported currantworm
         i. Damage: The larvae are 1/2 inch long, greenish in color, while the immature have dark spots. They feed along leaf margin and may defoliate the plant when they become numerous. Sawfly adults are black with yellow markings.
         ii. Control: Use insecticide according to label recommendations for currantworm on gooseberries.

e. Two-spotted spider mite
   i. Damage: Adults are 1/5 inch long, tan or greenish in color with two spots on each side of the back. They overwinter as adults on weeds and debris near host plant. Feeding reduces plant vigor and causes stippling on leaves. Webbing, when severe, may cause leaf drop.
   ii. Control: Insecticidal soap.

X. Elderberries

A. Elderberries belong to the genus Sambucus and grow wild over much of the United States and Canada. The blue or black varieties are edible. The fruit, born in flat clusters, makes excellent jelly, jams, pies, and wine. Most elderberries require cross-pollination, and all are hardy to Zone 4 (-30° to -20°F).

B. Cultivars in Idaho
   1. Adams—A strong plant with huge clusters, this variety produces sweet fruit.
   2. Johns—This variety bears later than the Adams and produces best when it has been cross-pollinated. It also has huge clusters of large, sweet fruit.
   3. Nova—Pollinate the Nova with the York. The plant produces large, sweet fruit.
   4. York—This hardy, late plant produces the juicy, sweet fruit that is the largest fruit of any elderberry. Pollinate the York with the Nova.

C. Culture
   1. Soil—The elderberry grows on about any soil type, but prefers moist, well-drained, siltloam soils, neutral to slightly acidic.
   2. Irrigation and fertilization—The plants need to stay evenly moist. Fertilize lightly, as the root system is shallow.
   3. Weed control—Elderberries can be grown in sod. Mulch with 4 to 6 inches of sawdust to control weeds and conserve moisture.
   4. Propagation—Plants are spread by stolons. Propagate with hardwood, greenwood, or root-cuttings.
   5. Pruning—This vigorous plant requires pruning to control size and maintain productivity. Cut a few main shoots to the ground each year. Prune out all wood more than 4 years old.

D. Common Plant Problems—Diagnosis and Control
   1. Diseases—None.
   2. Insects—None.

XI. Grapes

A. Grapes account for one-fourth of all fruit production in the world. They are used for wine and juice, preserves, and are eaten as raisins or table fruit.
   1. Grape production in Idaho is limited by cold winter temperatures and, in many locations, short growing seasons.
   2. All grapes in the Genus Vitis have vines that are generally vigorous and deep rooted. Grape varieties are self-pollinated. Fruit is borne on current season's growth.

B. Cultivars in Idaho
   1. Types of grapes
      a. European (*Vitis vinifera*): European varieties produce a tight-skinned wine, raisin or table grape. Quality wine types are made from them. Most viniferas require a mild winter such as those in California or Arizona (hardy only to about 10°F). Thompson seedless falls in this group and will not be hardy in Idaho.
      b. American (*Vitis labrusca*): American varieties have a slip skin and a musty or "foxy" flavor. The Concord is a typical example. Some are quite winter hardy.
      c. French and American hybrids: These are crosses intended to combine the quality of European grapes with the hardiness and disease resistance of American grapes.
   2. Cultivars
      a. Betas: This plant is a productive American blue-black variety with a tangy, wild grape flavor. It is good for jelly and juice and is hardy to -40°F.
      b. Black Monukkas: While this grape is one of the hardiest of the European plants, it still requires winter protec-

tion in many parts of Idaho. The fruit is large, reddish-black, and mostly seedless. It is sweet and good fresh.

c. Campbell's Early (Island Belle): A Concord type with early fruit, this variety is good for juice.

d. Concord: An American, blue-black plant with a vigorous, hardy vine, this variety is cold-resistant to -15°F. The fruit has a distinctive flavor.

e. Fredonia (Early Concord): Another American variety similar to the Concord, though it bears fruit earlier, this plant is hardy to -40°F.

f. Himrod: An American variety with a golden yellow, seedless fruit, this grape makes a good table grape. The Himrod is hardy to -15°F.

g. Interlakan Seedless: A sister of Himrod, the plant is similar, but more productive. It is hardy to -15°F, vigorous, and disease resistant.

h. Reliance: The Reliance produces a fine quality, seedless grape that is pinkish-red in color and has an excellent sweet, fruity flavor. This variety is disease resistant and hardy to -34°F.

i. Van Buren: An American Concord, this sweet table grape is hardy to -20°F.

j. Worden: Another American Concord, except larger and darker, this variety is good for juice and jelly and good served fresh. Worden is disease resistant and hardy to -50°F.

C. Culture

1. Planting

a. Plants: Many plants are produced from dormant cuttings. Some cultivars are budded or grafted onto disease, insect, and nematode resistant rootstocks. Rootstocks can modify vigor (increase or decrease) and provide tolerance to a wide range of soil conditions.

b. Soil: Grapes require a deep, well-drained soil for their extensive root system. Highest yields are on sandy loams. Grapes worldwide are planted on an extreme range of soil types. Rootstock may be necessary to tolerate some soils.

c. Spacing: Depends on the vigor of cultivar, soil, and training system used: 8 feet for American grapes and 6 feet on poor soils (sandy or gravelly) and 9 feet plus for vigorous European grapes.

d. Orientation: Maximize sunlight; plant on a south-facing slope; place rows north to south.

2. Irrigation—Required for most sites in Idaho.

3. Fertilization

a. General: Nitrogen fertilizers are detrimental to a fruit set. Most vines have over-vigor problems. Only very old or stressed vines may require nitrogen boost.

b. Potassium and phosphorus: Needs are low. See Subsection D, "Common Plant Problems: Diagnosis and Control."

c. Micronutrient: Boron deficiencies are common. See Subsection D on common plant problems.

4. Training and pruning

a. Types

i. Cordon or spur pruned (Fig. 4): Permanent canes or cordons are trained on a wire 40 to 45 inches from ground. Spurs are established along a cordon which bear fruiting canes each year. A second wire, placed at a height of 5 feet, is used to tie up fruiting canes in midseason.

ii. Cane-renewal system or Kniffen training (Fig. 5): Probably the best system for the homeowner in Idaho. A strong trunk is developed up to the second wire with spurs established at the trunk near the wires. Two canes with 10 to 12 buds are left as fruiting wood on wires; two to four spurs are left on the base of the cane to grow renewal wood.

Fig. 4. Bilateral cordon training on vertical trellis.

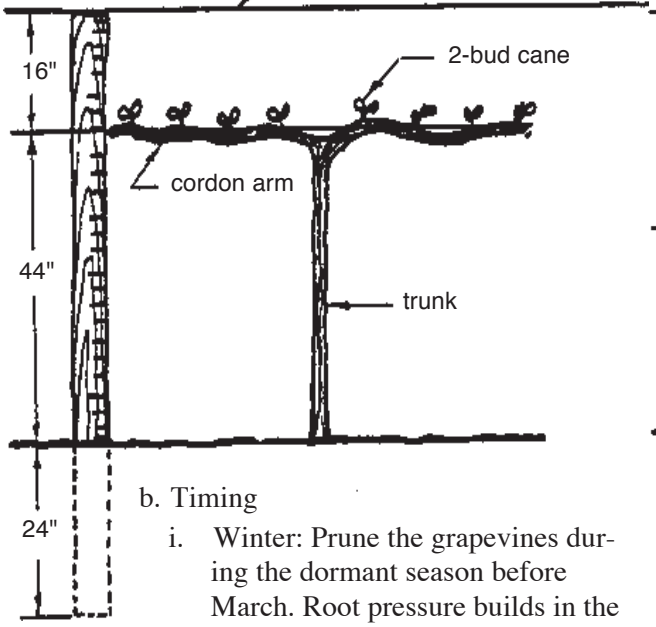
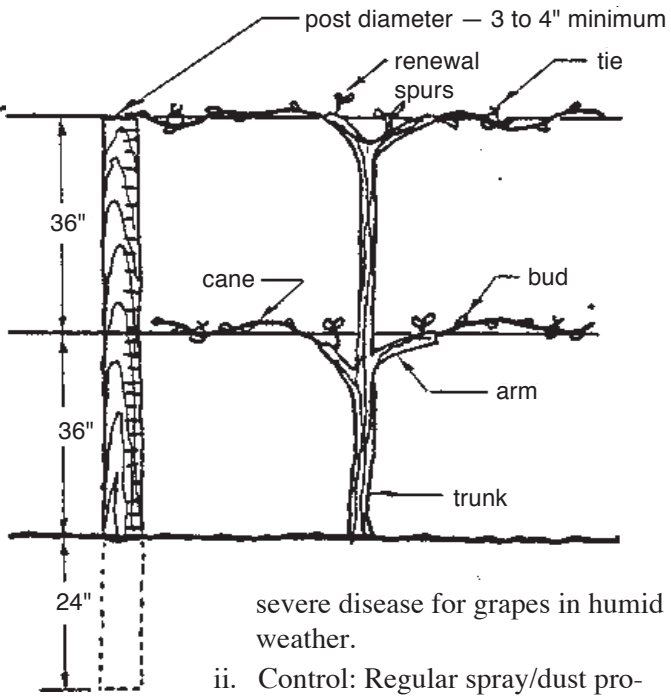


Fig. 5. Two-wire vertical trellis Kniffin trained.



b. Timing

i. Winter: Prune the grapevines during the dormant season before March. Root pressure builds in the spring and that leads to "bleeding" of water from plants. This has little harmful effect on plants, but it is best to avoid this period.

ii. Summer: Vigorous vines require summer maintenance. Yearly removal of suckers from the base of the plant or on the trunk below the first wire is needed.

iii. Pinching or heading back: The current season's canes will top the wire and flop into the row. Head back to keep plant upright and to prevent shading of clusters.

iv. Leaf removal: On late season grapes, remove leaves near clusters to provide air circulation and to lessen the chances for the development of bunch rot. Normally detrimental to overall vine vigor due to low sunlight.

D. Common Plant Problems—Diagnosis and Control

1. Diseases

a. Powdery mildew

i. Symptoms: This disease is the big limiting factor to home production of European grapes. It is the most severe disease for grapes in humid weather.

ii. Control: Regular spray/dust programs of sulfur are essential. Use according to the label. Many recommended American grape varieties are resistant.

b. Botrytis mold: "Noble rot" for producing a late harvest, sweet wine on many white wine varieties. Not desirable most of the time.

i. Symptoms: Early infections cause spotting on leaves, or infection sites on cluster stems. Bunch rot also occurs during the late season on ripening grapes.

ii. Control: Fungicide sprays according to the label for botrytis on grapes.

2. Insects

a. Caterpillars: Includes cutworms.

i. Symptoms: Feed on buds and shoots.

ii. Control: Pick off at night or use *Bacillus thurengiensis* (B.T.).

b. Scale

i. Symptoms: The scale may be round to oblong depending on species and may also have waxy excretions.

ii. Control: Apply insecticide according to the label instructions for scale on grapes.

c. Leafhoppers

i. Symptoms: These torpedo-shaped insects hold their wings in a rooflike position when at rest. They cause leaf injury and secrete honeydew.

ii. Control: Insecticidal soap sprays.

3. Other

a. 2,4-D injury: Grapes are very susceptible to damage by 2,4-D. It has been known to drift for miles and to affect plants.

i. Symptoms: Terminal growth can be misshapen; venation becomes parallel and fan-shaped; young leaves are thickened and distorted.

ii. Control: Avoid 2,4-D use around grapes. Wait for plants to grow out of problem.

b. Boron deficiency

i. Symptoms: There will be a light set of fruit, while the flower clusters will be affected with a "burning off." Terminal shoots may die in early summer, or show leaf chlorosis. Some European grapes are particularly affected.

ii. Control: Soil or leaf analysis is recommended and foliar sprays of soluble boron should be applied to correct the deficiency.

c. Potassium deficiency

i. Symptoms: Chlorosis of outer margins of leaves will leave a dark green area (Christmas tree effect) in the center of leaf and brown spots on the margins.

ii. Control: Apply potassium.

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University of Idaho Extension

Small Fruits

CIS 932	Blueberry Production: Overview
BUL 815	Growing Blueberries in the Inland Northwest & Intermountain West
BUL 821	Growing Western Huckleberries
PNW 215	Highbush Blueberry Production
CIS 815	Northern Idaho Fertilizer Guide: Blueberries, Raspberries, Strawberries

Strawberries

BUL 810	Growing Strawberries in the Inland Northwest & Intermountain West
CIS 931	Strawberry Production: Overview

Raspberries

PNW 598	Commercial Red Raspberry Production in the Pacific Northwest
CIS 341	Crumbly Fruit in Raspberries
CIS 789	Diseases of Raspberries in Idaho
BUL 812	Growing Raspberries and Blackberries in the Inland Northwest & Intermountain West
CIS 960	Raspberry Production: Overview
CIS 847	Virus and Nematode Diseases of Raspberries

Grapes

CIS 790	Backyard Grapes
RES 162	Contribution of the Grape and Wine Industry to Idaho's Economy
BUL 828	Economic Feasibility of Growing Wine Grapes in Idaho
CIS 1043	Selecting Grape Cultivars and Planting Sites in Idaho

Kiwifruit

PNW 507	Growing Kiwifruit

Washington State University Extension

Small Fruits

EB 1015	Small Fruits and Berries: Insect Disease Control for Home gardens
EB 1082	Raspberry and Strawberry Root Rots in Home Gardens
EB 1388	Small Fruit Pests: Biology, Diagnosis and Management

Grapes

EB 0637	Training and Trellising Grapes for Production in Washington
EB 1615	Critical Temperatures for Concord Grapes

To order Washington State University publications, write Extension Publishing and Printing, Cooper Publications Building, Washington State University, Pullman, WA 99164-5912.

Slides

Small Fruits, 117 slides, Eugene Memmler, P.O. Box 94475, Pasadena, CA 91109

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Chapter 24
Houseplants and Home Greenhouses

JoAnn Robbins, Extension Educator, Jerome County, Jerome

Houseplant—Any plant grown indoors, typically in a container. There are three groups of houseplants: foliage, flowering, and cactus and succulents.

I. Environmental Conditions and Requirements

A. Plant Needs

Understanding plant needs and existing conditions helps you to be successful with houseplants. All plants don't have the same needs, and average home conditions are basically inhospitable for plants. Normally, conditions are minimally appropriate for a few species. For success you have to be selective and manipulate the environment.

B. Light

1. Lack of light is the major constraint to indoor plant growth.
2. Light intensity refers to the amount of light available at a particular site. It is measured in foot-candles or lux (1 foot-candle = 10.7 lux).
   a. 50 to 75 foot-candles (fc) are the minimum necessary for plant growth.
   b. Light is reduced by the reciprocal of the square of the distance from the measured source. In other words, light levels diminish rapidly as you move away from the window or the lighting fixture. For instance, if you measure the intensity of light 1 foot from a window at 100 fc the following applies:
      i. 1 foot from window = 100 fc.
      ii. 2 feet from window = $100/2^2 = 25$ fc.
      iii. 3 feet from window = $100/3^2 = 11$ fc.
   c. An easy way to measure light is with a 35mm camera with a built-in light meter. Set ASA = 100, aperture to f4. Take reading of a white paper or board filling the camera's viewfinder. Light intensity is reciprocal of appropriate shutter speed (e.g., 1/100 = 100 fc). Hand held light meters designed for photography will accomplish the same task.
3. At low light levels, most common houseplants are classified as long term perishable and should be replaced every 2 years or so.
4. Increasing light
   a. Move your plants to a sunnier window with less overhang, less shading from trees, and a southern exposure.
   b. Move your plants closer to the window.
   c. Provide reflected light to plants by using white walls and mirrors.
   d. Provide artificial light (see section "VIII-h" on greenhouse lighting).
      i. Fluorescent bulbs provide low intensity light. For example a 40 watt bulb at a distance of 2 feet only provides 50 fc of light.
      ii. Incandescent lights are also low intensity. A 60 watt bulb at a distance of 2 feet provides 17 fc of light.
      iii. High intensity lights such as mercury vapor, sodium, and metallic halide provide significantly higher levels of light intensity.

iv. Most non-flowering foliage houseplants benefit from receiving light 12 to 16 hours/day.

5. Symptoms of light anomalies.
   a. Low light: Plants not receiving enough light become weak, spindly, and have long distances between nodes. Leaves turn yellow and drop, usually beginning from the bottom of the plant. Growth ceases. Variegated plants revert to solid green.
   b. High light: Plants receiving too much light have leaves that are light colored. The old leaves curl under and develop brown scorched spots or margins. New leaves are thickened.

C. Temperature
   1. Most indoor plants are of tropical origin and do not do well in cold temperatures.
      a. Most plants will tolerate a fairly broad range (55° to 85°F).
      b. Plants prefer 75°F days and 65°F nights (in general, 10 degrees cooler at night than in day).
   2. The direction the window faces affects temperature. South and west facing windows receive more sun, so tend to be warmer than east and north facing windows.
   3. Plants lose heat, or radiate, to anything colder. Place sheets of newspaper between plants and windowpanes on frosty nights to avoid cold damage to houseplants.
   4. Symptoms of temperature anomalies.
      a. High temperatures: If a houseplant is receiving too much heat the leaves will turn yellow, wilt, drop, or scorch.
      b. Low temperatures: If temperatures are too low, leaves will curl up, turn brown, and drop off.

D. Humidity
   1. Most houseplants prefer a high relative humidity. However, many will adapt to low levels of humidity.
   2. Heating systems differ in drying air. Normal humidity inside buildings (especially in winter) is much lower than the lowest range tolerable for good plant growth.
   3. Methods to raise humidity.
      a. Group your houseplants together to use the water vapor created by transpiration of other plants to increase the humidity level.
      b. A gravel tray beneath the houseplant pot filled with water will provide extra humidity as the water evaporates. Be sure that the base of the pot sits on the top of the gravel and does not touch the water.
      c. Humidity can be increased around a houseplant by misting. However, the effect is very short in duration and must be repeated frequently for any beneficial effect.
      d. Place plants in areas of high humidity, such as the kitchen or bathroom.
      e. Provide a double pot for your houseplants. Place moist sphagnum moss between the inner and outer pots to provide extra humidity.
      f. Increase the humidity level in the entire room with a humidifier.
   4. Methods to lower humidity.
      a. Ventilate the area around the houseplant by opening doors and windows and by using fans and air conditioners.
      b. Be sure not to over water plants or have water standing in trays beneath pots for any length of time.
   5. Symptoms of humidity anomalies.
      a. Low humidity: Plants growing under low humidity may develop brown leaf tips and yellow leaf margins. The plant may have stunted growth, or none at all, and will display signs of bud and leaf drop, shriveling, and wilting.
      b. Excessive humidity: Too much humidity will cause the plant to decay and rot. Its leaves and stems will darken, be susceptible to bacterial and fungal invasions, and show soft wilt.

E. Irrigation

Irrigation is the most important and most abused cultural practice with houseplants. Water relations are much more critical for potted plants because of their limited root space and the necessity for soil aeration.

1. Water requirements vary by plant species from constantly moist to mostly dry. You need to know individual plant requirements, which can be learned by consulting a reliable reference.
2. Water use is dependent upon a number of factors.
   a. Ratio of foliage to pot size: A large plant in a small pot may need to be watered daily due to the large amount of water lost and the small soil reservoir.
   b. Potting media: Sandy potting soil will hold less water than soil with peat or other organic matter. Plants in a sandy mix will need to be watered more often.
   c. Temperature: If temperatures are high, houseplants transpire freely, and water will evaporate rapidly from the soil surface. Plants in warm conditions will need to be watered more often.
   d. Humidity: Plants in dry air will transpire more and will need watering more often than those in moist air.
   e. Air movements: Plants located in a breeze will transpire more and will require more water.
   f. Light: Plants that are photosynthesizing will be exchanging gasses through open stomates and will allow transpiration to occur. Plants in brighter light areas, therefore, will require more water than those in dimly lit areas.
   g. Plant species: Some plants simply need more water to grow and be healthy than others.
   h. Container porosity: Clay and unglazed ceramic pots "breathe" and will lose water more quickly than glass, glazed ceramic, or plastic pots, so plants in clay and unglazed ceramic pots will need more water.
3. Water quality varies, particularly in the amount of soluble salts present. Well water in Idaho is often "hard." Many softening processes replace the calcium in the water with sodium that is damaging to houseplants; thus, be sure to water houseplants with water that has not been softened by this method. The amount of chlorine found in city water systems generally is not sufficient to cause problems with houseplants. Alkaline water makes growing acid-loving plants such as azaleas and gardenias difficult. Generous use of acidic peat moss and acid-reacting fertilizers will help offset the alkaline content in the water.
4. All containers should have drainage. Lack of drainage saturates the soil and excludes air from the roots. This condition leads to root rot.
5. Water temperature is important. Many houseplants are tropical, and adding cold water to their roots can harm them. African violet and other gesneriad leaves will be bleached by cold water. To avoid problems, water your houseplants with barely warm or tepid water.
6. Methods to determine the relative amount of water in a pot include checking with a finger one inch or so below soil surface for moistness, comparing the "heft" or weight of the pot, or tapping the side of the pot and listening for a hollow sound. The main thing is to check plants regularly.

Note: Inexpensive moisture meters actually measure conductivity (salinity) of the soil and are not reliable.

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7. The amount of water held and available is dependent upon media ingredients. Peat moss, field soil, and vermiculite hold the most. Sand, perlite, and pumice hold the least.
8 Symptoms of water-related anomalies.
   a. Not enough water: Foliage of broad-leaved plants darkens and turns crisp; the lower leaves will drop, and plants gradually wilt. The leaves and stems of succulent plants turn pale and shrivel.
   b. Too much water (or insufficient drainage): Leaves curl, wilt, blacken, and

drop. Corky scabs or protrusions form on the undersides of leaves or on branches. The leaves and stems become soft and the roots rot.

F. Fertilization
   1. Nutrients needed for plant growth are generally obtained from "real soil" that your potting mix does not usually contain.
   2. There is a limited supply available to houseplants because of the finite size of the pot. Also, the potting soil is usually "artificial" mix that contains little to no nutrients.
   3. The best method is to provide a constant supply of nutrients at relatively low levels.
      a. Nutrients will be particularly important during periods of growth.
      b. Don't over fertilize. You will get lanky growth, fertilizer burn, and the possibility of root damage.
      c. During the winter months, when home temperatures are apt to be cooler and days are short, decrease or eliminate fertilization to give plants a short rest of 2 to 3 months.
   4. There are many types of fertilizers. It is best to use a complete fertilizer that provides nitrogen, phosphorus, potassium, and micronutrients such as iron.
      a. No one type of fertilizer is better than the others. Slow-release granules let out a little fertilizer at each watering. Dry fertilizers or fertilizers that dissolve in water can be applied.
      b. Organic forms such as fish emulsion will provide micronutrients and low amounts of nitrogen. Fertilizer burn is less likely with an organic source.
   5. It is best to fertilize with soluble inorganic fertilizers when the soil is already wet. This way there is less of an uptake shock and, subsequently, less possibility of root damage and/or fertilizer burn.
   6. Fertilizer is not a cure-all; it will not make a sick plant healthy. In fact, fertilizing a plant with disease or other stress and, hence, forcing growth may be the final stress that kills it.
   7. Nutritional deficiencies
      a. Macronutrients
         i. Nitrogen (N): Lack of N results in a stunted plant with yellow leaves; older leaves fade first, then turn brown and die.
         ii. Phosphorus (P): Lack of P results in retarded growth. The plant remains a deep green leaf color until it turns purple or bronze (or mottled in light and dark tones). The symptoms are apparent in older leaves. Another symptom is retarded flowering.
         iii. Potassium (K): Lack of K creates tip and marginal burn on lower leaves. These burns advance up the plant. The leaves crinkle and turn inward, and the plant stops growing.
      b. Micronutrients
         i. Deficiencies in anything more than N, P, K, or iron are unusual. If the addition of a balanced fertilizer doesn't cure deficient symptoms, repot plant in new soil and resume a regular fertilizer schedule.
         ii. Iron (Fe): Leaves turn yellow, while veins remain green. The plant will have stunted growth and curled leaves.
         iii. Excess chlorine (Cl): Too much chlorine causes thickened leaf tissue, which becomes brittle. Great excesses of Cl burn and destroy plant roots.

G. Salt Damage

   Salt damage is a common problem in house plants, and steps must be taken to avoid it in order to have healthy plants.
   1. Salt build up is indicated by a crusty white substance coating the top of the soil or the rim of the pot.
   2. Salt build up is caused by repeated fertilizing, giving plants too little water at a time, high salt concentrations in tap water, and poor drainage in pots.
   3. The symptoms of salt damage are easy to spot.

a. Plants will not grow well.
b. Leaf tip and marginal leaf burn are evident. Roots are burned and deteriorated. You may also see thick, dwarfed leaves with sunken breathing pores on leaf undersides.

4. To avoid salt build up in pots:
a. Do not water houseplants with water softened by sodium salts
b. Water plants with distilled water; it contains no salts or minerals.
c. Flush excess salts out of pots periodically (monthly) by watering heavily and repeatedly until water pours out of the drainage holes.
d. Repot plant in new soil and new pot.
e. Wash old pots well before reusing for houseplants. Soak clay pots in several changes of clean water to flush out salts absorbed by the clay.

H. Overall Environmental Factors Affecting Plant Growth
1. Plants are living things. The keys to healthy houseplants are to minimize stress and provide a favorable environment with minimal variation.
2. Don't overcorrect. Don't make up for underwatering with overwatering. Don't make up for lack of light by placing plant in direct sun. Shocks like this will not benefit growth.

II. Media, Containers, and Potting

A. Root Media
1. Because of the physical limitations of the container, houseplants need specialized media. Do not use straight field soil. It lacks correct physical properties. It is best to buy a potting mix from a garden center.
2. There are some important properties to consider when choosing a container media.
a. Roots need air to grow, so the percentage of air-filled space for houseplant soil needs to be 10 percent or more.
b. Container media needs to hold enough water to supply what the plant needs. Pure sand makes a poor container media, as the soil must hold water equal to 40 percent of volume or more.
c. Container media needs to be able to hold nutrients (have a high cation exchange capacity). Organic matter will help increase nutrient-holding capacity.
d. The pH (acid balance) of the soil needs to be favorable for houseplant growth. A pH range of 5.5 to 6.5 is best.
e. Container media must be free of diseases and toxic substances.

B. Container Choice
1. No one container material is better than another, but each container type requires different management. All containers require drainage holes at the bottom.
2. Basic container materials.
a. Clay pots are attractive, and plants grow well in them because they breathe and allow air exchange through their walls. As a result, they will dry out faster than other types of pots, and plants will require more frequent watering. They also tend to accumulate salts in their walls because of the evaporation. These can be flushed out of empty pots by soaking them in several changes of clean water.
b. Plastic pots are readily available and come in colors to complement your decor. They are impervious to water, and their walls do not breathe. Because of this, soil aeration of the media is particularly important. The soil will also hold the water longer, so less frequent watering will be necessary.
c. Fiber pots are inexpensive and rustic looking. They are porous and allow a limited amount of air and water exchange. The bottoms of these pots tend to break down and fall apart over time.
d. Wooden pots are attractive but they tend to leak out of the cracks if not lined with a plastic interior. When lined, they essentially become a plastic container.
3. When using saucers, it's best to lift the pot above the saucer so that after irrigation the pot doesn't sit in drained water. If it does sit in water, be sure the water is all taken up within an hour or two. Sitting

in water for days at a time will cause the soil to be saturated, which will eventually kill a plant. Decorative containers that hold the entire pot (jardinieres) can be used and should be treated just like saucers.

4. When reusing containers, be sure to clean them well to reduce any carryover of insects or diseases found in plant parts or old soil clinging to the plants. Soaking clay pots in fresh water for several days will leach out any accumulated salts. Scrub other pots with a stiff brush and detergent, and rinse in a solution of bleach.

C. Repotting Houseplants

1. There should be a balance between top growth and container size. Too small a container will cause rapid water loss, and too large a container will keep the soil saturated and lead to root problems.
2. When potting, cover the drainage hole with old nylon stocking or pottery shard to minimize soil loss when irrigating. Do not use gravel in the bottom as it only reduces the effective pot size and does not help drainage.
   a. Do not press or tamp soil firmly in pots as this reduces aeration. Rather, tap the filled pot on a table to settle soil and remove air pockets.
   b. Leave a 1-inch head space at the top of pots for irrigation.
   c. Media containing peat moss that has gotten bone dry may need to have the moisture kneaded in before using it for potting. If this isn't done, penetration of the water in the repotted plant will be extremely slow until the peat absorbs the water. In the meantime the roots are completely dry.
   d. Water immediately after potting. It's best to irrigate two times to be sure soil is settled well around the roots and that the media is completely wetted.
3. Repot if compacted or salt-filled soil, poor drainage, soilborne insects, inadequate nutrition, and crowded roots.
   a. Move up only one pot size at a time. A general rule is to make the internal size of the container about 1 inch larger all around than the old pot.
   b. Replant the plant at the same level on the stem as in an old container.
   c. How often to repot depends upon the plant's rate of growth, root condition, and media characteristics.
4. Terrariums typically have no drainage, so use activated charcoal at the bottom of the container and water less.

III. Controlling Size and Shape

A. Phototropism

Houseplants orient their leaves toward a fixed light source. To keep a balanced shape, rotate plants frequently.

B. Pinch

Frequently remove terminal growth such as vines and branching plants to keep them bushy and within bounds.

IV. Diagnosis of Problems

A. Be Observant

1. In diagnosis the most difficult task is not to jump to conclusions. Don't be absolute, even though the problem seems obvious. This is particularly true if you are being guided by a description of a problem without actually seeing the plant.
2. Ninety-five percent of all problems with houseplants have to do with light, water, humidity, and fertilization. Frequently, the problem is a combination of these factors. Diseases are usually a result of some environmental stress.
3. Be methodical in your questioning. Ask step-by-step questions about plant care and conditions.
4. Learn to ask questions the right way. Not, "Are you watering correctly?" Rather, "How often do you water?" Get a quantitative answer that will help you decide if the watering is correct.
5. Look at the roots of the plant. Roots should be healthy and growing.
6. Symptoms overlap so brown tips on the ends or edges of leaves are symptomatic of several problems. It is up to you to ferret out what is causing them.

V. Insect Pests

Watch for insects when you introduce new plants to a home. Most insects are brought in with new plants and plants that have been outside in the summer. They also hitchhike in on pots, equipment, and your clothes, shoes, and person.

Pests have preferences for certain plant species. Thus, some plants are more prone to insect problems.

A. Major Insect Pests

1. Aphids—These are soft bodied, small round insects that mass around growing tips and tender tissue. Aphids suck plant juices. Their invasion causes deformed and curled new leaves, buds, and flowers. Some carry virus diseases and some species cause galls. They all secrete honeydew, and this is sometimes the first symptom noticed. The honeydew attracts ants who feed on it.
2. White fly—This small white winged fly congregates on undersides of leaves. Small immature crawlers, or larvae, suck sap and secrete honeydew. Adults fly up in a random pattern when disturbed and resettle to the plant surface quickly.
3. Scale—These are small, hard, immobile, disk-like insects. Scales suck plant juices. Their presence causes leaves to develop yellow spots, turn yellow, and drop off. They also have a crawler stage that moves about until it matures. This crawler becomes the disk-like immobile adult that is obvious.
4. Mealy bugs—Mealy bugs are scale insects that are covered with layers of white waxy substance. Mealy bugs look like little cotton pieces. They suck sap, resulting in stunted growth, wilting, defoliation, and eventual plant death. They also secrete honeydew.
5. Spider mites—Spider mites are tiny, eight-legged arachnids that proliferate rapidly in hot dry growing environments. They suck sap, causing pale blotches, loss of color, and dry, rusty leaf textures. The leaves tend to turn gray, yellow, or to be smothered in fine, mealy cobwebs before dropping off. They can be seen, although they look like moving dust unless viewed with a magnifying lens. They most often congregate on the undersides of leaves.
6. Cyclamen mites—These microscopic voracious feeders cause distorted, blotchy bloom; stunted, twisted, or shriveled stems; and leaves with stunted and compact plant centers. Their presence is often followed by the dropping off of flower buds and streaky, purplish foliage. These mites are difficult to eradicate. As their name implies they are a particular problem in cyclamen, but also affect other houseplants.
7. Leafminers—The larvae of fly, moth, sawfly, or beetle leafminers eat leaf tissue between the upper and lower leaf surfaces causing slender, winding trails, tunnels, and blisters on leaves.
8. Fungus gnats—Light attracts these tiny black flies. The flies zig and zag in irregular flight when disturbed before settling back down on the soil surface. The eggs of fungus gnats hatch into threadlike white maggots that burrow through the soil, embed themselves in root tissue, and eat small feeding roots, root hairs, and crowns of plants. The plants suffer from root rot, slow weak top growth, and yellowing leaves. Root feeding produces wounds that can permit entry of disease organisms.

B. Insect Control

1. It is essential to quarantine all new plants introduced into your home until you are sure they are pest free.
2. Several effective nonchemical insect control methods are available.
   a. Water: Keep all plant leaves clean by washing or spraying with water. This is especially good for control of aphids. Putting the plant in the bathtub to give its leaves this shower works well.
   b. Soapy water (use specially formulated insecticidal soaps): Sponge or spray onto leaves. This works well on spider mites and aphids.

c. Rubbing or denatured ethyl alcohol: Use alcohol on a cotton ball, tissue, or swab to remove insects such as scale and mealy bugs. This works well on large, stiff leaves. Be sure to test first to make sure the alcohol will not damage the leaves, especially on soft, thin, and fragile leaves. This is not practical on something with tiny leaves, and you must be sure to repeat often for complete control.

d. Yellow sticky boards: Insects are attracted to the yellow surface and become tangled in the sticky goo on the surface. These are best used early when infestations of flying insects are low. This is a good technique for white fly control.

e. Predators: These can be insects, nematodes, or mites. Some of these are very specific. They are effective in reducing pests, but may be difficult to keep on the plant and to maintain.

f. Replacement: If pest population is too high or complete control seems impossible, discard the plant and buy a new one.

3. Chemical controls for insects are available.

a. Use caution when using chemical insecticides. Read the label thoroughly and follow instructions carefully. Not only are excessive rates or unlabeled applications unhealthy for you, but they may cause plant damage or phytoxicity.

b. Use different chemicals for different problems or when one type stops working.

c. Be sure to use the chemical that will control the pest you have.

d. Understand the life cycles of pests and susceptible stages. If you must repeat applications, follow the timing precisely.

e. Some pests have developed a resistance to certain pesticides. If one is not effective, try another from a different chemical group. Do not increase dosage.

VI. Plant Diseases

Diseases usually occur in plants that are stressed by unfavorable environmental conditions. The most common stresses are high or low temperatures, overwatering, low light, overfertilizing, open wounds, air pollution, and excessive humidity.

Parasitic organisms, bacteria, or fungi can cause disease in houseplants.

A. Common Diseases

1. Anthracnose—This fungus is characterized by depressed leafy spots with dry centers. The entire end of the leaf may turn dark tan with darker bars crisscrossing the leaf.

2. Crown and stem rot—These fungal diseases cause stems and bases of affected plants to turn soft and mushy to the touch.

3. Damping-off—This disease is caused by a soilborne fungus that attacks the lower portion of the seedling stems, which then collapses. The leaves turn inward and look pinched. The seedling wilts and dies.

4. Leaf spot—This disease creates yellow-margined spots with dark brown or black damp or blistered centers. Bacterial or fungal invasions cause leaf spot.

5. Mildews and molds—Black sooty mold on leaves appears as black coating and can be associated with honeydew secreted by aphids, mealybugs, and scale. A white or grayish felt-like coating on foliage is mildew. It causes leaves to curl and shrivel. A gray or white mold on the soil surface can be fungus caused.

6. Root rot—Root rot invades roots and diminishes roots' ability to absorb water. This rot is fungus-caused. It damages new growth, which dies back. The entire plant eventually wilts and dies.

B. Disease Control

1. Correct the environmental conditions that are allowing the disease to thrive. For instance many rots thrive in excess water. Treatment is to lower the humidity and cut down on watering.

2. Pick off and destroy infected leaves and plant parts. Repot or replant in new media.
3. Apply fungicidal dusts or drenches as recommended, following label instructions for the specific disease.

VII. Propagation

A. Clone

Vegetative or asexual propagation produces a clone of the plant that you propagate from.

1. This is the most common commercial technique. It is fast and ensures genetic consistency. It is also easy to do.
2. Propagate by using cuttings from the stem, leaf, offsets, or stolons.
3. Air layering can be done with many plants by scoring the stem, wrapping with damp sphagnum moss, and enclosing in a plastic covering secured above and below by a loose tie.
4. Factors to consider when propagating houseplants:
   a. Be sure to start with vigorous, healthy plants.
   b. Use sterile, well-aerated rooting media. Most packaged mixes are sterilized before packaging. Peat mixed with either perlite or vermiculite makes a good rooting media.
   c. Pieces of plants cannot be under water stress while roots are forming. To maintain a good water balance, remove part of leaves on large-leafed plants, and raise humidity with enclosure or mist.
   d. Cuttings and newly rooted plants need light for photosynthesis. However, cuttings should not be in direct light unless they are under an automatic mist system. Newly rooted plants should be eased into high light situations gradually.
   e. Bottom heat (heat at root zone) helps plants to root. A temperature of 70° to 75°F with an air temperature of 60° to 65°F is ideal. Use a heating cable or mat to provide bottom heat.
   f. Use rooting hormones to stimulate root initiation and growth. These are applied as a dry powder or a solution in which the cutting is dipped.
   g. When placing cuttings in media, be careful not to wipe off the hormone.
   h. When roots have grown on cuttings to where they are large enough to support the cutting, transplant quickly since there is less transplant shock for small root systems.

B. Uniqueness

Seed or sexual propagation may produce an individual similar to the mother plant. With cross pollination, however, variation will occur, and the resulting seedlings will all be unique individuals.

1. With seed propagation you can produce more plants. Plant breeders use this method to produce new varieties using the variation produced by seedling variation.
2. Some seeds need a presowing treatment to break dormancy.
   a. Stratification, or a moist cold treatment, is needed for some.
   b. Scarification, or scratching or breaking down the seed coat, is needed for some.
3. Seeds from different species of plants have different light and temperature requirements.
4. Be sure to use sterile media to avoid seed rot and damping-off of seedlings.
5. Transplant seedlings when they become crowded. Be sure to lift plants by a leaf, not by the tender stem or growing tip.

VIII. Greenhouses

A home greenhouse is a satisfying addition for the home gardener. Many plants will grow in greenhouses including annual bedding plants, forced bulbs, cacti and succulents, geraniums, gloxinia, orchids, and tropical foliage plants. You can grow vegetables and fruits such as cucumbers, eggplant, lettuce, onions, peppers, radishes, strawberries, and tomatoes in a greenhouse.

The various plants require different temperatures and light conditions, so the size of the greenhouse and its cooling and heating equip-

ment may restrict the greenhouse grower to certain plants. Providing proper growing conditions is essential for successful greenhouse gardening.

A. Types of Greenhouses
   1. Attached lean-to—Built against a building, this greenhouse uses the building's walls for one or more of its sides. Usually, the width is limited to a total of 7 to 12 feet.
   2. Attached even-span—Similar to a free-standing structure, this greenhouse is attached at one gable end to a house or other structure. They are larger and more flexible than the lean-to type.
   3. Attached window-mounted—This reach-in unit replaces a window and is ideal for growing a few plants at low cost for heating and cooling.
   4. Free-standing—Set apart to get the most sun, this type of greenhouse can be as large or small as desired. With many shapes or frame types available, this type of greenhouse is the most costly to build and maintain.

B. Location and Orientation
   1. Light—Get the most light by placing the attached greenhouse on the south or southeast side of the structure. The east side is the second best location followed by southwest and west. A north exposure is the least desirable. Locate free-standing greenhouses where large trees, other buildings, and obstructions will not shade them.
   2. Shelter—Locate small greenhouses in a sheltered area to reduce wind-related heat losses. A windbreak or building located far enough away so as to not shade the greenhouse will provide shelter. Choose a site that has access to electricity, water, and an energy source for heat.
   3. Orientation—Once you have selected a site, orient the greenhouse to make the most of the available light. An east-west orientation (with the ridge of the house running east and west) is preferable, especially during the winter when light is most critical.

C. Design and Construction
   1. Shapes—Many styles of greenhouses are possible, such as Quonset, dome, gothic arch, A-frame, slant-leg, gable roof, and tripenta. Plans, kits, or finished houses are available from a variety of sources.
   2. Frames
      a. Wood: Wood contributes to uniform greenhouse temperature because it does not cool down quickly. Use a wood resistant to decay, pressure treated, or treated with non-toxic water-borne, salt-type preservative.
      b. Steel: Provides a more solid structure than wood and lets more light into the greenhouse. You must paint steel frames to prevent rust.
      c. Aluminum alloy: Lightweight and strong, aluminum frames offer a high degree of light reflectiveness and require little maintenance. They transmit heat readily, resulting in greater heat loss.
      d. Plastic: Light, strong, and readily available, plastic (especially PVC pipe) is good for hoop-house construction.
   3. Covering materials
      a. Glass: Use extra strength or tempered glass. Attractive, permanent, and expensive, it requires periodic recaulking. Leave construction to a manufacturer because glass is difficult to fabricate. A single layer has 90 percent light transmission.
      b. Plastics
         i. Rigid plastic: Resists breakage, is lightweight, and easy to install. Most degrade under sunlight.
         ii. Polyvinylchloride (PVC): Available in UV-treated form, PVC allows 88 to 90 percent light transmission. It is flexible, comes corrugated or flat, and lasts 2 to 7 years.
         iii. Clear acrylic (Plexiglas, Perspex, Transpex, and Lucite): Half as heavy as glass, acrylic plastics resist impact and are flexible but expensive. All but Lucite scratches.

Most types are available in double-walled panels that will last 20 years and allow 90 to 95 percent light transmission.

iv. Polycarbonate: More flexible and less expensive than acrylic, polycarbonate plastic yellows and loses transparency with age.

v. Film plastic: Inexpensive, but temporary, film plastic requires more maintenance. Ultraviolet (UV) radiation will destroy it if not treated with a UV inhibitor. Use double layer to reduce heat loss.

c. Polyethylene

i. Regular polyethylene: Not recommended because of its short life span (9 to 12 months). Stronger with increasing thickness, it usually splits on the fold. Allows 85 to 88 percent light transmission.

ii. UV-treated polyethylene: Lasts 1 to 2 years. Use 4 to 6 mil thickness. Keep clean to increase winter light; 85 to 88 percent light transmission.

iii. Co-polymer films (Monsanto 602): An ethylene and vinyl acetate, co-polymer films are stronger with a life of 2 years. Keep clean for an 85 to 88 percent light transmission.

iv. Reinforced polyethylene: Contains glass or acrylic fiber for additional strength and a 2-year life span. Keep clean for an 85 percent transmission.

v. Reinforced UV-treated polyethylene: Has similar characteristics to reinforced polyethylene.

vi. Vinyl films: Thicker (8 ml) types are hazy. Keep clean because they attract smog and dirt. This tears easily when punctured and will last for about 2 to 5 years. Allows 89 to 91 percent light transmission.

vii. Polyvinyl floride films (Tedlar PVF and Teflon FEP): An expensive type of film plastic that lasts 7 to 8 years with 92 percent light transmission.

d. Polyester

i. Polyester films (Molar, Melinex, and Llumar): This stiff plastic film tears easily when punctured and degrades rapidly in the sun.

ii. Acrylic laminated to polyester (Flexigard): Reduced UV radiation breakdown and tearing gives this type of plastic a moderately long life.

e. Fiberglass

i. Durable, attractive, and moderately priced, fiberglass is more resistant to impact than glass and much lighter.

ii. Use UV-treated fiberglass because the untreated types will yellow with age. If not treated with UV-resistant materials, the fibers become exposed or "fray." Low maintenance, fiberglass lasts for a year untreated and 15 to 20 years if UV treated.

iii. With a 75 to 90 percent light transmission, fiberglass is not recommended for plants with high light requirements in areas with less than 40 percent sunny days in the winter.

iv. Fiberglass comes corrugated or flat. It is flammable. Buy only clear (not colored) types of high grade fiberglass.

4. Benches

a. Side benches: Because you access side benches from only one side, they should be no wider than what you can reach across (generally 2 to 3 feet). Leave about 6 inches between the benches and the side walls for air-circulation.

b. Center benches: Because you access center benches from both sides, they can be as wide as 6 feet. Small greenhouses may have room only for side benches.

c. Other types: Beds, shelves, and imaginative types of benches are all possible in a greenhouse. Tailor them to your needs and plant requirements.

5. Walkways and flooring
   a. Walkways should be easy on the feet, well drained, and non-slippery.
   b. Use pea gravel, ready-mix concrete, porous concrete, treated wood, brick on a sand bed, porous aggregate, or stepping stones in any combination for walkways and flooring.
6. Heating
   a. Heating capacity will depend on size of greenhouse, the type of covering, and the coldness of the external temperature and wind relative to the desired inside temperature. Attached greenhouses often can use the home heat source for warmth.
      i. Conventional: You can use coal, electricity, gas, or oil heat sources. You can use these sources to heat the air directly in a forced air system or to heat water for a hot water or steam system. Use an approved flue to vent gas, oil, and coal. Electricity is often too expensive to use.
      ii. Solar: By capturing the sun's heat in water, stone, concrete, or similar heat-absorbing material, you can heat your greenhouse via radiation during non-sunny periods. You should combine solar heat with other methods such as double walls, covers, and blankets to minimize heat loss from the greenhouse.
      iii. Blankets and shutters: Movable blankets and shutters can serve as nighttime insulation. They are only as effective as the operator who must faithfully open and close them. You can make these interior insulating systems from black or clear polyethylene film, aluminized fabric, PVC laminate, spun-bonded polyester, foam-backed fiberglass drapery material, woven and lofted polyester, or clear plastic bubble wrap. Fit them on tracks, rollers, or slides or secure with hooks.

         Shutters are foam insulation boards that you cut to fit between wall studs and ceiling rafters. Foam with aluminum foil facing is even more effective. Wood turn knobs or magnetic clips will hold the panels in place. They are more effective than thin blanket materials but are labor intensive to install and require a larger storage space.
      iv. An alternative is external blankets or insulation. They are more expensive to build, however, because they must be weather resistant. Sleet and snow are difficult to remove, and the operator must go outside to install them.
7. Ventilation and cooling
      i. Ventilation: Ventilation equipment will help control temperatures in all seasons. Hand-operated side or roof vents require constant supervision. Automatic ventilation is simple to install and requires only an electric motor, thermostat, and a pulley or gear system.
      ii. Fans provide good ventilation. You can use them alone or in combination with other vents. Vent fans to draw in the outside air or to recirculate internal air. Fans in combination with a polyethylene duct will help to distribute the air evenly throughout the greenhouse.
      iii. Exhaust fans will draw out the heated air. Usually, you install them near the roof line to prevent drafts. Use in conjunction with a second vent such as a louvered shutter that opens when the exhaust fan starts. Place the vent at a lower level so cool air moves across the greenhouse, mixing with warmer air.

Note: Wire all fans to a thermostat set at the temperature desired before beginning ventilation.

      iv. Cooling: When the external air is not cool enough to provide internal cooling for the greenhouse, you should use evaporative coolers or mist blowers to cool the air. Evapo-

rative cooling draws outside air through wet fiber pads that cool the air and add some moisture to it.

v. Mist blowers use fans that blow mist from a fine jet of water into the greenhouse. The mist cools the air and provides needed humidity. Control all cooling systems automatically with thermostats.

vi. Shading: Shading can reduce the need to ventilate and cool a greenhouse because it curtails the amount of radiation entering. Shading also protects plants from the direct rays of the hot summer sun and reduces light intensity. Often needed from June to August, you can provide shading by whitewashing the greenhouse, attaching blinds or panels, or by covering the house with shade or saran cloth.

8. Lighting

In the greenhouse, you may need to supplement natural light, especially during the long winter nights. Light controls most plant functions, so it is important to understand the needs of your plants.

a. Light quality: Plants use red and blue portions of white light for various plant functions. It is important to have red/orange light for germination, maturation, and flower and seed production. Plants use blue/violet light for growth and leaf development. Artificial lights must supply the proper light spectra.

b. Light intensity: Some plants require bright light to grow, while others prefer shady (less intense light) areas. Light is measured in foot-candles or lux (see section "I.B" on Light).

c. Light duration: A photoperiodic effect is the response of a plant to the length of the light and dark periods. Flowering is the most dramatic effect associated with the length of exposure to light.

i. Short-day plants respond to a day-length of less than 12 hours.

ii. Long-day plants respond to a day-length of longer than 12 hours.

iii. Day-neutral plants do not respond to the variations in the light-dark cycle.

iv. If you want flowering in certain plants, you need to provide the proper daylength. You do this by extending the days with artificial light, or if the days are too long, by shading the plants with an opaque black cloth supported on a frame.

v. Do not ever peek into the shaded area, however, as just a "flash" of light will destroy the long-night effect!

vi. To provide a longer day-length, the light intensity does not need to be as high as it would be for proper growing conditions.

d. Artificial lights: You can use various types of lamps in the greenhouse. A simple timer is ideal for turning the lights on and off.

i. Incandescent: These lamps give off red light and infrared radiation that becomes heat. They are not intense enough to supply light to plants with a high light requirement. Light distribution is restricted.

ii. Fluorescent: Fluorescent lamps produce less heat, and different types vary in their output in the red-blue areas. One cool-white and one warm-white bulb provide a good spectrum for plant growth.

iii. Mercury vapor, sodium, and metallic halide: These lamps provide high intensity lighting. They are expensive and more suitable to large-scale production.

e. Watering: In the home greenhouse, the traditional watering method is a mist or spray nozzle on a garden hose. The greenhouse gardener who is gone a lot can install automatic systems, such as mist nozzles, spaghetti tubes, or capillary mats.

i. In some areas, water quality is a concern. Water high in salts or high in alkalinity may need special treatment for greenhouse use.

IX. Small Beds for Growing Plants

A. Cold Frames

A cold frame is a bottomless box with a removable lid that you can prop open at various degrees. The lid consists of glass or other greenhouse covering material on a frame.

1. Cold frames do not require artificial heat or manure. They use the sun's heat to warm the soil during the day, and the heat's radiation in the closed cold frame keeps the plants warm at night.
2. During the day, control ventilation and heating by propping open the lid.
3. Use cold frames to plant seeds and produce transplants for main season gardens and for root cuttings.

B. Hotbeds

You can convert cold frames to hotbeds simply by adding a heat source such as manure, electricity, steam, or hot-water pipes. Start seeds or force plants in hotbeds.

1. The amount of extra heat needed depends on available sun and the external temperatures. Soil-heating cable that provides 10 to 15 watts of electric heat per square foot is ideal for most hotbeds. If the bed is in a sunny, well-sheltered location and the climate is not too severe; 10 watts per square foot should be adequate.
2. Attach your heat source to a thermostat or buy a heat cable with one to provide accurate temperature control in the 50° to 79°F range. On very cold nights, cover the beds with extra insulating materials.
3. Adding manure that heats as it decomposes is an effective practice that has worked for centuries. Modern gardeners, however, rarely use manure as a heat source.

C. Cloches

Protecting plants by providing a cloche, or miniature greenhouse, is standard practice for gardeners. The cloche offers only temporary protection until the outside temperature is favorable enough to produce good growth. Hot caps, commercial "Walls of Water," and 1-gallon plastic milk cartons with the bottom cut out are temporary structures that help moderate the temperature around plants.

1. Producing an entire crop under cover of a cloche is practical wherever the weather is unreliable or predominantly cool. Growing a crop in a cloche allows the gardener to produce plants that otherwise may not grow in the area. Cloches are suited to intensively managed gardens and severe climates. The cloche provides a constant warm temperature and prevents wind, rain, frost, and pest damage. They may be only the size of a single plant or large enough to cover several.
2. Cloches can have a frame of some type to support the covering material (use any greenhouse material or floating row cover). It may be necessary to use some type of venting system to reduce the heat that solar radiation produces. Construction and anchoring needs to be strong enough to withstand the wind conditions of the area. Often cloches are designed to last only 1 year.

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University of Idaho Extension

PNW 171 Building Hobby Greenhouses

PNW 151 Propagating Herbaceous Plants from Cuttings

PNW 170 Propagating Plants from Seed

CIS 881 Success with Very Small Seeds

CIS 858 Using Bark and Sawdust for Mulches, Soil Amendments, and Potting Mixes

Washington State University Extension

EB 0695 House Plant Pests

EB 1354 Houseplants

To order Washington State University publications, write to Extension Publishing and Printing, Cooper Publications Building, Washington State University, Pullman, WA 99164-5912.

Alberta Agriculture

Agdex 731-5 Hobby Greenhouses in Alberta

To order, contact Alberta Agriculture, 7000 - 113 Street, Edmonton, Alberta T6H5T6

Videos

How to Grow Healthy Houseplants, VHS 457, District III Extension Office, Twin Falls, ID.

Foliage Plants for Interiors, WSU/UI Regional Media Collection, 1 (800) 999-1765.

Indoor Plants, WSU/UI Regional Media Collection, 1 (800) 999-1765.

Plant Propagation: From Seed to Tissue, WSU/UI Regional Media Collection, 1 (800) 999-1765.

Slide Sets

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Chapter 25
Organic Gardening

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I. Organic Gardening Overview

A movement has been growing over the past several decades to produce food organically. The realm of gardening is no exception to this movement. Organic growing is more of a mind set rather than rules and regulations to be followed. It is striving to maintain a natural balance in the growing of plants.

This natural balance involves soil, plants grown, water, insects, beneficial fungi, and bacteria, wildlife, and other components that complete the natural equilibrium of living things. It is a holistic approach that includes using local materials as much as possible to replenish what is taken away from the total system.

Organic gardening does not allow the use of synthetic fertilizers or pesticides in the production system.

Organic gardening requires an added time commitment. Since one cannot rely on quick fixes through the use of synthetic materials, gardening organically often involves much greater hand labor, at least in the first few years until the garden plot becomes more naturalized to the organic practices being used.

Weeding will generally be the major effort for the first few years, but insect and disease pressures can also take considerable time to get under control organically. Once the problems are recognized and methods developed to deal with them the time commitment is reduced.

Organic gardening has many similarities to conventional gardening, yet there are important differences.

A. Definitions—Legal definitions of organically produced agricultural products must be met if the produce is intended for market. Find further information on growing plants and animals to be marketed as organically produced at: http://www.agri.state.id.us/Categories/PlantsInsects/Organic/indexOrganicHome.php.

Levels of organic production fall within the realm of organic growing of food that do not necessarily qualify legally as organically produced commodities. This chapter will give you some of the basics of growing in the organic tradition.

Basically organic production means growing crops and animals without the use of synthetically produced materials. In Idaho organically grown food means food products produced without the use of synthetically compounded fertilizers, pesticides, or growth regulators for a period of 36 months prior to harvest. To produce commodities and market them as organic, one must follow established rules. (See section IV for Idaho information.)

B. Organic pesticides—Organic pesticides can to be used by the organic gardener, but many problems exist that are difficult to solve without synthetic pesticides. Because of these challenges, it becomes very important to follow good husbandry practices when gardening in the organic tradition.

C. Site selection—The simple step of choosing a gardening site becomes very important when growing organically. If a poor site is picked the plants will be stressed and be subject to insect and disease problems that may be very difficult to control. Weeds can also be a serious problem in an organic garden. Very few herbicides exist that are able to be used in organic production.

Pick a site with good soil, good drainage, and adequate sunlight. Try and find one with few weed problems, if possible, espe-

cially noxious weeds. If the soil is poor, be sure to add organic matter to help with the tilth, fertility, water holding capacity, and organic content of the soil.

II. Soil Fertility and Amendments

Organic gardening begins with the soil. The healthier the soil the healthier the plants and the better success the gardener will have, be it an organic garden or otherwise. Given the limited resources to deal with pest problems, maintaining the health of the plants becomes paramount.

Soil aspects of organic gardening will need at least yearly attention. The addition of compost and other organic material is very important to replace nutrients lost in the production and harvesting of garden produce. The sources of this organic matter may be leaves from the trees, vegetables, kitchen scraps, lawn clippings, compost in its various forms, as well as other organic material that may be locally available.

Table 1. Average plant food content of natural and organic fertilizer materials (Percentage on a dry-weight basis.)

Organic materials	%N	%P	%K	Availability	Soil Reaction
Fish scrap	5.0	3.0	0	slowly	acid
Fish meal	10.0	4.0	0	slowly	acid
Guano, peru	13.0	8.0	2.0	moderately	acid
Guano, bat	10.0	4.0	2.0	moderately	acid
Sewage sludge	2.0-6.0	1.0-2.5	0.0-0.4	slowly	acid
Dried blood	12.0	1.5	0.8	mod. slow	acid
Soybean meal	7.0	1.2	1.5	slowly	v. sl. acid
Tankage, animal	9.0	10.0	15.5	slowly	acid
Tankage, garbage	2.5	1.5	1.5	very slowly	alkaline
Tobacco stems	1.5	0.5	5.0	slowly	alkaline
Seaweed	1.0	---	4.0-10.0	slowly	---
Bone meal, raw	3.5	22.0	---	slowly	alkaline
Urea*	45.0	---	---	quickly	acid
Castor pomace	6.0	1.2	0.5	slowly	acid
Wood ashes	---	2.0	4.0-10.0	quickly	alkaline
Cocoa shell meal	2.5	1.0	2.5	slowly	neutral
Cotton seed meal	6.0	2.5	1.5	slowly	acid
Ground rock phosphate	---	33.0	---	very slowly	alkaline
Green sand	---	1.0	6.0	very slowly	---
Basic slag	---	8.0	---	quickly	alkaline
Horn and hoof meal	12.0	2.0	---	---	---
Milorganite	6.0	2.5	---	---	---
Peat and muck	1.5-3.0	0.25-0.5	0.5-0.10	very slowly	acid
Spent mushroom compost	2.0	0.74	1.46	moderately	6.4

*NOTE: Urea is an organic compound, but since it is synthetic, it is doubtful that most organic gardeners would consider it acceptable.

Approximate nutrient content of soil amendment materials commercially available in bulk are listed in this table. It also gives information on availability of nutrients to soil and plants. Slowly available material means nutrients last relatively longer and are available to plants longer in the soil compared to quickly-released nutrients.

The soil reaction column indicates if the material will have an acidifying or alkaline impact on soil. For basic soils, adding acidifying material helps lower the pH.

Note: Tables 1, 2, and 3 are slightly modified from CIR375 of the Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original published in April 1993, it was updated in May 2003. Find it at http://edis.ifas.ufl.edu.

Compost is organic matter that has been broken down by microbial action, insect, and other invertebrate animals. Composting is a natural process that can easily be accomplished by the home gardener. For detailed information on the art and science of composting refer to Chapter 7 on Backyard Composting. The composting of material treated with synthetic pesticides is not allowed in organic gardening.

Both inorganic and organic fertilizers can cause plant burn, groundwater contamination, excessive buildup of toxic materials in the soil, and plant nutrient excesses and deficiencies. To avoid these problems, it is important to have an understanding of the types and amounts of nutrients you are applying to the soil when you add any type of material to your garden.

Organic matter is the main source of fertility in organic growing systems. Since synthetic fertilizers are not permitted in organic gardening it sometimes becomes challenging to find and provide the necessary nutrients the plants need. Before planting the garden, it should be fertilized with needed components. Plants will get needed nutrients through the compost and other organic matter added yearly to the soil.

Usually plant nutrition is in the form of animal manures, plant manures, cover crops, compost, compost tea, or mixed organic fertilizer. Animal manures are generally the most complete source of nutrients for organic gardening but there are several other sources that can be utilized. Refer to tables 1, 2, and 3 to get a relative idea of which types of organic matter add what nutrients to the soil. There are mineral sources for certain nutrients for the organic gardener.

Green manures have been shown to benefit organic gardening. Not only do they add organic matter to the soil, many of them have the ability to reduce insect, disease, and weed problems. Members of the Brassica family, especially the oil seed radishes, contain natural chemicals that inhibit and kill soil-inhabiting pest problems.

The three tables that follow offer guidance on managing your compost piles to meet needs in your soils. Chapter 4 Soils and Fertility, page 8 in this book explains the significance of macronutrients N (Nitrogen), P (Phosphorous—designated P_2O_5 as phosphate in fertilizers), and K (Potassium—designated K_2O or potash in fertilizers).

Table 2. Composition—fresh manure with normal quantity of water.

Kind of manure	%Water	%N	%P	%K
Cow	86	.55	.15	.50
Duck	61	1.10	1.45	.50
Goose	67	1.10	.55	.50
Hen	73	1.10	.90	.50
Hog	87	.55	.30	.45
Horse	80	.65	.25	.50
Sheep	68	1.00	.75	.40
Steer or feed yard	75	.60	.35	.55
Turkey	74	1.30	.70	.50

This table gives an approximate amount of the noted nutrients that are added to the compost pile when composting fresh manure. The finished compost will vary in nutrient level depending on composting efficiency.

Table 3. Composition of various materials thrown into compost piles.

Compost material	%N	%P	%K
Banana skins (ash)	---	3.25	41.76
Cantaloupe rinds (ash)	---	9.77	12.21
Castor bean pomace	5.00	2.00	1.00
Cattail reeds	2.00	0.81	3.43
Coffee grounds	2.08	0.32	0.28
Corncob ash	---	---	50.00
Corn stalks & leaves	0.30	0.13	0.33
Crabgrass, green	0.66	0.19	0.71
Eggs, rotten	2.25	0.19	0.15
Feathers	15.30	---	---
Fish scrap	2.00-7.50	1.50-6.00	---
Grapefruit skins (ash)	---	3.58	30.60
Oak leaves	0.80	0.35	0.15
Orange culls	0.20	0.13	0.21
Pine needles	0.46	0.12	0.03
Ragweed	0.76	0.26	---
Tea grounds	4.15	0.62	0.40
Wood ashes*	---	1.00	4.0-10.00

The composition of materials commonly found in or near the home are listed. If your soil is deficient in a certain nutrient, add material to the compost pile that is high in that nutrient to raise its level in the finished compost.

*Note: Do not compost wood ashes if you are going to apply the finished compost to alkaline soil.

III. Dealing With Pests

The first approach to fighting pests is cultural control methods. In some cases this is the only option. For organic growing, the goal is to reach a stability or balance between pests and desirable plants. This balance comes about by maintaining diversity within the system. Reaching a good diversity level in a small garden plot is somewhat more difficult than in a large-scale operation, but it is a sound concept to strive for at any level of organic production.

The first thing to do is to be sure to practice crop rotation. Crop rotation is the practice of rotating different families of plants in the same area in the garden. For example, if you plant potatoes one year then tomatoes the next year you are planting crops within the same family. This encourages both soil borne and above-ground pests that cause problems in this family to increase.

On the other hand, following carrots, which tend to compact the soil, with corn, which tends to loosen the soil, helps soil tilth. Very few pests attack both of these crops.

- Higher crop yields—Through crop rotation the garden area reaps several benefits. Higher crop yields have been demonstrated when crops are rotated.
- Microbial biomass—There is also an increase in soil microbial biomass, which helps ward off soil borne diseases and increases carbon dioxide generation.
- Nitrogen increase—There is also an increase in soil nitrogen (related to the increased microbial biomass), which can decrease the need to add additional nitrogen.
- Drainage and moisture-holding—Crop rotation has also been demonstrated to increase drainage and moisture holding capacity and reduce soil compaction.
- Weed suppression—Another great benefit of crop rotation is in weed suppression. Different crops are prone to different types of weeds. For example squash is considered a weed suppressive crop because it shades the ground and inhibits weed seed germination while corn is generally widely spaced and takes some time to grow sufficiently to shade out weeds.

IV. Pest Control Strategies, Idaho Information

One may think that any organic substance would be allowable for use in organic production. This is not the case. For example, tobacco dust (nicotine sulfate) is not allowed in Idaho because of its extreme toxicity. Federal and state regulations list what materials may be used in organic food production. In Idaho, get detailed information by writing to IDA Division of Ag Inspection, PO Box 790, Boise, Idaho, 83701-0790.

V. Weed Control

Weed control is probably the most challenging part of organic gardening. Very few acceptable organic chemical controls are available for fighting weeds.

A. Vinegar—One notable exception is vinegar, which has been shown to control many annual weeds when used at 10 to 20 percent strength. Household vinegar is typically about 5 percent. In its concentrated state, vinegar can cause burns and eye damage. Availability is somewhat limited, but as the demand grows it will become more available in local nurseries. Sources can be found on the Internet. As with any pesticide, care should be taken when using vinegar for controlling weeds.

B. Corn gluten—Corn gluten is another herbicide that may be used in organic growing. Used as a pre-emergent, it has been shown to be effective against a large number of weeds. It reduces weed seed germination with no apparent effects on transplanted materials. It is also effective in lawns as a pre-emergent herbicide. Corn gluten can usually be found in well stocked nurseries and also on the Internet.

C. Cultivation—The most common way to control weeds is through cultivation. In small garden plots, the hoe becomes your best friend. In larger gardens, a rototiller can be used effectively, especially if crop rows are properly spaced. A drawback to the use of rototillers is that they can damage crop roots if you go too deep or too close to desirable plants. Another disadvantage is that you can create a hardpan in your soil through the repeated use of a rototiller. As

the tines go down into the soil and rotate they tend to compact the soil just below the depth of the cultivation. Overall, however, rototillers are a great asset in the battle against weeds.

D. Mulching—Mulching is a very effective way to keep weeding to a minimum. Almost any material that will allow moisture to reach the soil but keep the light off the soil will work as a mulch. Such things as compost, sawdust, grass clippings, leaves, weed matting, newspapers (non-colored inks), black plastic with perforations to allow water to reach the soil, as well as many other items will greatly aid in the fight against weeds. Make sure the mulch is thick enough to keep sunlight from hitting the soil surface, but do not pile it so high as to reduce oxygen in the soil, or start the composting process, which could produce heating problems around the desirable vegetation. Probably 4 inches is a good maximum depth. Mulching can be done anytime of the year.

E. Thermal weeding, flaming—Another technique that saves time in a large garden is thermal weeding or flaming. This method dehydrates weeds and is very effective. It can be used as a pre-plant, pre-emergent, post-emergent, or pre-harvest treatment.

   A device such as a propane burner is lighted and passed over the tops of the offending weeds just before planting the desired crop. A good technique in pre-emergence crops, especially in carrots and beets, is to allow weeds to germinate, and then plant crop seeds among weed seedlings. Wait about a week, then flame the weeds in the pre-plant state, thus allowing seeds to sprout in a weed-free environment.

   During post-emergence and pre-harvest, take care to keep heat of the flame away from desirable vegetation, either by distance or use of heat-resistant shields, such as tin or other metal. Also use pre-harvest flaming to remove potato foliage prior to harvest.

F. Soil solarization—A method of controlling weeds, soil dwelling insects, and soil borne diseases is soil solarization. Soil is more or less pasteurized through the heat of the sun. Benefits include reduction of pest problems and stimulation of beneficial organisms.

   First, till the soil to enhance the conduction of heat, moistening the ground to be treated to at least one-foot deep.

   Then place clear plastic over the soil. Anchor the ends securely to keep the plastic in place. This technique is mainly useful in USDA Zones 5 and above. If you live in a Zone 4 or less, the generated heat units will probably not be sufficient to heat the soil enough to kill very many weed seeds, insects, or disease organisms.

G. Soap-based and oil-based herbicides—Some soap and oil-based herbicides are cleared for organic food production. They work by burning the foliage back and can be effective in certain situations. When using them be sure to keep desired vegetation protected because they will burn the leaves of all plants. They generally are not effective in controlling perennial weeds.

H. Other methods—Other methods also may reduce weed pressure.

   1. Weed-free manure/mulch—Make sure manure and mulch sources are weed free if possible.
   2. Remove weeds—Be sure that weeds are removed from the garden before going to seed.
   3. Check equipment—If you borrow equipment, check to see that you do not bring in weed seeds from soil or other matter adhering to the equipment.
   4. Avoid weed hitchhikers—Vehicles, clothing, and animals may also transport weed seeds.
   5. Composting—Composting weeds that have weed seed attached is not a good plan. If the composting process is done incorrectly, weed seeds may survive and become a problem.
   6. Timing planting—The timing of planting may prevent weed pressures. For example, mustards are generally an early spring problem. Delaying planting until the mustards have emerged and been removed may reduce weed problems.

7. Avoid bare soil, green manure—Maintain a crop cover instead of leaving bare soil to inhibit or prevent weed seed from germinating.

   To accomplish this, use green manures before or after the crop is put in. Green manures such as winter rye, buckwheat, mustards, oil seed, radishes, crimson clover, hairy vetch, or subterranean clover have all demonstrated the ability to suppress certain weeds.

8. Geese—Several species of geese have been used successfully to weed out grasses from crops and may be of some use in a garden.

IV. Insect Control

The best control of insect pests is through maintaining healthy plants. Many insect pests are attracted to unthrifty plants. An ounce of prevention is indeed worth a pound of cure. Insects can pose serious problems in an organic garden. It is vital that you scout your garden for insects and try and control them before they have a chance to multiply. Three methods can be used to control insects organically: Mechanical control, biological control, and insecticides (chemical control).

A. Mechanical Control

Mechanical control is the first line of defense in combating insect pests.

1. Remove by hand—Probably the most common and effective way to control insects is to use the tried and true method of removing them physically from the plants. This method is very effective in a small garden. You can either pluck them from the surface or use a leaf to squash them. You will also be able to see egg clusters and remove them before they hatch.
2. Water jet—Another easy way to remove certain insects from plants is to use a strong jet of water and wash them off the plant. This is especially effective with aphids. Once on the ground, aphids become prey for several ground dwelling predators.
3. Floating row covers—A very effective defense against flying insects are floating row covers, available at well-stocked lawn and garden stores. They work by physically excluding access to the crop by flying insects. Row covers are generally not effective against soil dwelling insects. They need to be in place before the insects have a chance to lay eggs on the plants. Floating row covers are effective in controlling lepidopteron larvae (caterpillars), flying pests of onions, carrots, and some leaf mining insects, as well as other pests.
4. Sticky traps—Sticky traps used in combination with insect attractants can be effective.
5. Bug vacuums—Bug vacuums available commercially are very useful in removing large numbers of insect pests. However, they remove all insects, including beneficial ones. If you have beneficial insects helping you out, then this is a less attractive method.
6. UV bug zapper—Should you be tempted to use a UV bug zapper to control insects, be aware that you will probably kill more beneficial insects than injurious ones.

B. Biological Control

This method uses insect predators, parasites, and pathogens to help control pestiferous insects. When using this method of control, it is important to recognize and understand beneficial insects, their life cycles, and how to maintain them.

1. Strategies
   a. Plant diversity—Plant diversity is important in maintaining a viable beneficial insect population. Many helpful insects are nectar feeders so flowering plants are desirable. Many plants in the Apiaceae (formerly known as Umbelliferae) family—such as fennel, angelica, coriander, dill, parsley, and wild carrot— provide several tiny flowers needed by parasitoid wasps. Clovers, yarrow, and rue also attract parasitoid and predatory insects.
   b. Low-growing plants—Ground-dwelling beneficial insects such as ground beetles seek low-growing

plants for protection. Thyme, rosemary, or mint provide such shelter. Composite flowers, such as daisy and chamomile, and mints attract predatory wasps, hover flies, and robber flies.

c. Safe haven—If possible, dedicate a small area of the garden to plants that attract beneficial insects. Think of it as a safe haven. Insects will be able to maintain their populations by living off the deleterious insects in nearby untreated areas.

2. Helpful beneficial insects

The following is a partial list of organisms that can be used to your advantage in combating insect infestations:

a. Ladybird beetles (ladybugs) —These familiar insects are very beneficial in consuming soft-bodied insects, especially aphids and mealy bugs. Both adults and larvae dine on these pests, but the larvae consume substantially more than do adults. The larvae somewhat resemble miniature alligators and many gardeners think they are harmful, so make sure you recognize them.

Ladybird beetles may be purchased from several sources. Be sure to have some way to contain them, such as a fine meshed net or a tent (be careful to ventilate to avoid heat buildup) for a few days when you release them to get them established in your backyard. When first released they have a tendency to disperse and mate.

b. Lacewings—These insects also prey on soft-bodied insects, eggs, and mites. Adults have delicate wings and a faint smell of moth balls. The larvae, as with ladybird beetles, are voracious eaters. Lacewing eggs are laid singly on a stock and are fairly common in organic as well as conventional systems.

c. Wasps—Many wasp species parasitize several different orders of insects. They are generally very small and pose no threat to humans. They attack insect eggs, larvae, and adults.

d. *Bacillus thuringiensis* (Bt) —Several strains of this bacterium have been very effective in controlling insect pests. They form a crystal that is toxic to certain insects but not to warm-blooded mammals.

The crystal is dissolved in insects' digestive systems. When first discovered, these bacteria were found to be very useful in controlling lepidopteran pests (caterpillars), including codling moths and cabbage loopers. Since then other Bt strains have been found that are effective against certain coleopteran pests (beetle family) including Colorado potato beetles. For this control method to work, the material has to be eaten by the insect. Several products on the market contain Bt. Make sure you purchase the type that is effective against pests you are trying to control.

Unfortunately, some resistance to Bt has begun to show up in certain insect populations, especially the diamond back moth, a pest to cole crops, so caution is advised when using Bt as a control. Whenever there is a possibility of a pest species gaining resistance to a certain control strategy, it is very wise to rotate control methods.

In several crops, this toxin has been genetically engineered into the plant. Any genetically engineered plant or other organism is not acceptable in organic production.

e. Nematodes—These organisms are microscopic simple roundworms. Several nematodes are available that control several soil borne pests. Nematodes may be purchased at many well-stocked lawn and garden outlets. When purchasing them, be sure you know the targeted pests you wish to control because the nematodes have a fairly specific host range. They have been shown to be very successful in controlling certain insect pests when applied strictly according to label instructions. They are very sensitive to desiccation (extreme drying) and to ultraviolet radiation.

Nematodes especially beneficial for Idaho pests include:

1) *Heterorhabditis bacteriophora*—for root weevils on ornamentals, billbugs, and scarabs (June beetles) in lawns and also for root weevils in berries
2) *Steinernema feltiae*—for fungus gnats, and
3) *S. carpocapsae*—for armyworms, cutworms webworms, girdlers, and wood borers.
4) Other nematode species may also be effective. There are undoubtedly other nematodes that will be developed to control problem insects.

3. Beneficial Fungi

Specific fungi are commercially available that have shown control in aphids, whiteflies, leafhoppers, flies, beetles, caterpillars, thrips, mites, and some beetle larvae. These fungi may also attack beneficial insects. Under the right conditions they can be very effective, but as with most fungi, humid conditions are usually needed for efficacious control. *Beauveria bassiana* is the most common fungal insecticide used.

4. Beneficial Viruses

Certain viruses are effective in controlling insect pests, mainly in the Lepidoptera (moths) family. To be effective, viruses must be consumed by the insect. As with the other biological control methods mentioned here, these viruses pose no threat to human health. They also do not directly cause problems for insect predators. Viruses are currently limited in their availability but through diligent searching one may find a source. The Internet may be of benefit, or universities and private companies involved in this line of research.

C. Chemical Control

At first thought, the use of pesticides in organic gardening seems incompatible with the total concept of organic gardening, yet several pesticides are used in organic production. They are not synthetically made, however, and materials allowed in organic pest control are subject to close scrutiny.

The fact that pesticides are considered all right to use in organic food production and are naturally derived does not mean that they are non-toxic. Some allowed substances are very toxic, and it is vital that labels be read and understood before using any pesticide. Just as common chemicals are given toxicity ratings, so are chemicals from botanical and mineral-bearing sources. "CAUTION" means low toxicity or fairly safe to use; "WARNING" means moderately toxic; and "DANGER" means highly toxic.

To qualify as an organic pesticide, the product must be from natural sources, cannot be genetically modified, and must be certified as a pesticide that is useable in organic food production.

The following insecticides are some of the more common ones currently registered in Idaho for use in organic production. This is not a complete list. New pesticides become available to the organic grower on a fairly regular basis.

Each state may recognize different chemicals as proper to use in organic production. If you are growing produce to sell organically, be sure to check the most current information. Contact information for Idaho is listed at the end of the chapter.

1. Pyrethrum/pyrethrin

Extracted from chrysanthemums, this pesticide affects the nervous system of insects and is very effective against a wide variety of insect pests. Several formulations available, some containing ingredients are not allowed in organic production.

One common additive—piperonyl butoxide (PBO)—is not permitted in organic production systems, so be sure to read the label when purchasing pyrethrum-based insecticides. Several instances of allergic skin reactions have been reported, so take care to keep it off your skin.

Pyrethroids are synthetically made materials based on the chemistry of natural pyrethrins. Because they are synthetic, they are not allowed for use on organic crops.

2. Boric Acid

   Boric acid has been used for a long time in controlling pests. It is allowable in organic production systems as long as it does not get on edible portions of the plant. There are various bait and dust formulations.

3. Diatomaceous Earth

   This material is composed of fossilized skeletons of microscopic water plants called diatoms. They extract silica from the water and incorporate it into their skeletal systems. When they die their skeletons form a diatomite deposit. After being ground, this material turns into very small glass-like particles able to cut the cuticle of insects and cause desiccation. It is fairly safe to use, but the dust can irritate lungs and eyes.

4. Sabadilla

   Derived from seeds of the sabadilla lily, the active ingredient is an alkaloid known as veratrine. It is both a contact poison and a stomach poison. Sabadilla is one of the least toxic of the botanical pesticides. It can, however, be highly irritating to eyes and can cause sneezing if inhaled. Sunlight quickly inactivates this material so applications in the evening are best.

5. Neem

   Used in India and Africa for more than 4,000 years for medicinal and pest control purposes, neem is derived from seeds of the neem tree, a native of India. Compounds derived from the seeds have both insecticidal and fungicidal properties. Neem blocks a molting hormone in insects and terminates the molting process. Effective against a wide range of insect pests, neem is effective, but not a fast-acting insecticide, so do not expect quick results. It has a very low mammalian toxicity.

6. Rotenone

   A compound produced by the roots of two members of the Leguminoceae family, rotenone is effective on leaf-feeding insects such as caterpillars, beetles, aphids, and thrips. As with neem this is a slow-acting chemical. Insects stop feeding shortly after ingesting the material. This material is extremely toxic to fish but only moderately toxic to most mammals.

7. Horticultural, Summer, Dormant Oils

   Oils, effective against a wide range of insects, are only to be used on woody plants. They can be very effective in controlling things like scale, mealy bugs, and insect eggs, coating and smothering insects and their eggs. Oils are relatively more effective against active insects than dormant ones. Several different, and sometimes confusing, names are used for horticultural oils.

   Heavier oils are used during the dormant period—late winter and early spring—on woody plant material, so are called dormant oil. Summer oils, or horticultural oils, are lighter in consistency and relatively safe to use when plants are in leaf, but may cause leaf burn. Most horticultural oils are petroleum-based, but other types of oils—neem, vegetable, and fish—can also be effective.

   Sulfur is sometimes a problem in horticultural oils, and some oils have a "UR" (unsulfonated residue) rating. The higher the UR rating, the lower the sulfur content. Most horticultural oils have a UR rating of 90 or above. Oils are fairly safe around beneficial insects because most of them have the ability to escape. Some beneficials, such as predatory mites, will succumb to oil applications since they cannot remove themselves from harm's way.

   Oils such as carrot and weed oils are not permitted for use in organic production.

   A few plant species are very sensitive to oil applications, among them Japanese and red maple, hickories and black walnut, plume cedar, and smoke tree. Other sensitive plants are redbud, junipers, cedars, spruce, and Douglas firs. If you apply oil to a blue spruce, the blue color will be lost.

8. Insecticidal soaps

   Insecticidal soaps are very safe and useful in controlling a wide variety of insects. Many gardeners are tempted to

substitute household soaps instead of buying the material that is labeled for insect control. All clothes detergents will cause harm to your plants as will most other forms of dry soaps, usually by burning the foliage. Insecticidal soaps are formulated with potassium salt of fatty acids. Commercially available insecticidal soaps are selected to control insects, to minimize potential plant injury, and are of consistent manufacture.

9. Sulfur

   Sulfur is probably the oldest known pesticide in use. The Greek poet, Homer, described the benefits of "pest-averting sulfur" 3,000 years ago. It can be used in several forms such as a dust, wettable powder, paste, or liquid. It can help control spider mites, psyllids, and thrips and can be used on a variety of crops including beans, potatoes, tomatoes, and peas.

   It also is used on a number of fruit crops such as apples, cherries, grapes, peaches, pears, plums, and prunes. Sulfur is relatively safe to use, although it may cause eye and skin irritation, and, if applied when temperatures are above 90°F, it can burn the plant. Also, it reacts with other pesticides so it is best to apply it alone. If you use oils, be sure not to use sulfur within 20 to 30 days as sulfur and oil react together to cause phytotoxicity.

10. Other products

    Several other effective products are available to control insects and are certified for use in organic production, including garlic and herb preparations, lime sulfur, insect extracts, pheromones, etc. As you gain experience with organic gardening, you will become more familiar with these products. Several books and online resources to help you further resolve pest problems, along with references and additional reading material, are at this chapter's end.

VII. Disease Control

As with insect control, the best way to control diseases is to maintain healthy plants. Choosing the proper plants for the garden, matching the plant to the soil type, proper light levels and irrigation needs, correct sanitation, and proper fertilization and pruning will go a long way to maintaining a healthy garden.

Prevention is extremely important when it comes to dealing with plant diseases. Once established, diseases are almost impossible to eradicate from stricken plants, and they act as a reservoir for infection of healthy plants. Don't start out with a disease problem. Purchase disease-free stock. Generally, vegetatively-propagated material will have some type of certification stating it is either virus free or, at worst, has low levels of virus present.

In fighting diseases, remember the disease triangle. The three components needed to have disease are: a susceptible host, a pathogen capable of causing disease, and the proper environment for the disease to thrive.

Armed with this basic knowledge, one can approach disease control from several angles. For example, if you have problems with your tomatoes and *Verticillium* wilt, probably the easiest way to correct it would be to purchase *Verticillium*-resistant tomato plants. Many garden vegetables that are susceptible to *Verticillium* wilt have cultivars with resistance bred into them.

Another approach to minimizing disease is to remove diseased plant material, thus reducing the pathogen population. Such steps as removing fallen diseased leaves, pruning out diseased portions of a plant, or removing the entire diseased plant will help reduce disease pressure.

Most plant diseases are caused by fungi. Fungi like high humidity. By changing the environment through such things as drip irrigation and wider spacing of plants, the overall humidity is reduced thus decreasing the chances of fungi-causing problems.

Organic fungicides are available that are fairly effective against several disease problems faced by gardeners. As with herbicides and insecticides, fungicides should be used only after other controls have failed.

Popular Fungicides. Below is a brief discussion on some of the more popular fungicides used by organic gardeners.

A. Sulfur.

   In addition to being an effective insecticide, sulphur has fungicidal properties and is effective in controlling and suppressing sev-

eral plant diseases. First used some 2,000 years ago by the Greeks to control rust on wheat, sulfur is used as a preventative fungicide, which means it has to be on the plant surface before the disease gets inside the plant to be effective.

It is useful against powdery mildews, rose black spot, rusts, and other diseases. It works by inhibiting the germination of the fungal spores. It is available in several forms, including dusts, liquids, and wettable powders.

Keep in mind that sulfur can burn foliage if the temperatures are above 80°F and if oils have been used within the last 20 to 30 days. Plants sensitive to sulfur include apricots, some raspberries and blackberries, gooseberries, currents, and cucurbits.

B. Lime Sulfur

Lime sulfur is made by boiling lime and sulfur together. The lime helps the sulfur penetrate the plant tissue. This mixture has insecticidal properties as well as fungicidal properties. It helps control diseases such as anthracnose and powdery mildew when used as a dormant spray. It also aids in the control of scale insects, thrips, and eriophyoid mites.

Drawbacks to using lime sulfur are its smell of rotten eggs, and it can burn exposed skin and eyes. It will also injure plants if temperatures are above 80°F.

C. Bordeaux Mixture

This is a natural pesticide produced by a reaction between copper sulfate and calcium hydroxide (hydrated lime). It was first used in Bordeaux, France, to control downy mildew on grapes, hence its name.

Like sulfur, Bordeaux is a preventative fungicide that needs to be in place before the disease shows up. It has a very long track record—more than 150 years. Fungicidal as well as bacterial properties extend its utility in organic production.

Bordeaux has the advantage of sticking to plants despite rain or irrigation. It controls bacterial leaf spots, blights, various types of anthracnose, downy mildews, and cankers. It also repels many insects.

Uses. Bordeaux is labeled for use on many vegetables, tree fruits, and nut crops.

Drawback. One drawback is that, like sulfur and lime sulfur, it can be phytotoxic to plants. It can burn leaves and cause russeting of fruits if applied in cool wet weather.

Formulations. There are various formulations of Bordeaux mixture, but perhaps the best all-around mix is 4-4-50—four pounds of copper sulfate and four pounds of hydrated lime in 50 gallons of water. Generally a weaker solution of Bordeaux is recommended for foliage in early spring and a heavier solution for late in the season applications for protection against serious diseases like late blight.

Copper caution. One caution to keep in mind with Bordeaux mix is that excessive use will cause a buildup of copper in the soil. Copper is toxic to fish and is a heavy metal. Bordeaux fungicide can be purchased pre-mixed, but it is more effective if prepared just before use. Plants, including ornamental sorghum and corn, are sometimes sensitive to copper-based pesticides. Also, use caution when applying Bordeaux to tender leaves of apple, pear, plum or rose as they may be burned. Geraniums, ivy, pansy, celery, strawberry, azaleas, dogwood, and juniper are also sensitive and dilute sprays are advised.

D. Other Fungicide Options

Neem oil has fungicidal properties. Hydrogen peroxide, dormant oils, the antibiotics streptomycin and tetracycline, as well as several mineral and plant based materials can be valuable in protecting your crop. The further reading section at the end of the chapter and online resources will aid your search for solutions to problems.

E. Seek Reliable Data

When using compounds to control pests in an organic system, it is advisable to make sure reliable data supports its use and that it is registered for use on the intended plant species you wish to treat. Many homegrown recipes are purported to solve all sorts of problems. In some cases, they may be effective but may also cause unwanted side

effects, such as buildup of harmful compounds in the soil, unexpected detrimental effects on beneficial fauna and flora, and possible toxic generated materials and side effects.

VIII. Summary

Gardening organically can be very rewarding. Through the process one will gain a much greater appreciation of natural checks and balances. Once we are able to work within the parameters nature has defined for us, we will gain a deeper understanding of how natural processes work in our favor. Organic food production involves a certain state of mind, as well as a defined food production system. Organic growing involves a holistic approach to growing, instead of the more common approach of treating problems individually. There will certainly be a learning curve associated with this approach, but once the gardener understands how things interrelate, the process becomes much more manageable and enjoyable.

Further Reading

Books

Ball, J. 1988. *Rodale's Garden Problem Solver; Vegetables, Fruits, and Herbs*. Rodale Press, Emmaus, PA. ISBN 0-87857-762-9.

The Encyclopedia of Organic Gardening, 1978. By editors of *Organic Gardening Magazine*. Rodale Press, Emmaus, PA. ISBN 0-87857-225-2

Ware, W. W. 1988. *Complete Guide to Pest Control With and Without Chemicals*. Thomas Publications, Fresno, CA. ISBN 0913702-09-9.

Booklets and Pamphlets

University of Idaho Extension

CIS 1066	Composting at Home
PNW 550	Encouraging Beneficial Insects in Your Garden
PNW 533	Fertilizing with Manure
CIS 993	Management of Vegetable Diseases in Home Gardens
BUL 775	Planning an Idaho Vegetable Garden
PNW 328	Using Horticultural Mineral Oils to Control Orchard Pests
EXT 726	Weed Control in the Home Garden

Oregon State University Extension

EC 1247 Gardening with Composts, Mulches, and Row Covers

PNW Insect Management Handbook. Oregon State University, Administrative Services-A442, Corvallis, OR 97331 ISBN 1-931979-12-X

PNW Plant Disease Management Handbook. Oregon State University, Administrative Services-A442, Corvallis, OR 97331 ISBN 1-931979-12-X

PNW Weed Management Handbook. Oregon State University, Administrative Services-A442, Corvallis, OR 97331 ISBN 1-931979-12-X

Utah State University Extension

HG-510 Selecting and Using Organic Fertilizers

Washington State University Extension

EBO 648 Organic Gardening

Web Sites

Organic production and certification information. http://www.attra.org/organic.html

Idaho State Department of Agriculture Organic Growing Information and Requirements. http://www.agri.state.id.us/Categories/PlantsInsects/Organic/indexOrganicHome.php

Idaho OnePlan provides data and software to help growers develop a single conservation farm plan that can be pre-endorsed by the various agencies, streamlining and simplifying the regulatory process that farmers face. http://www.oneplan.org/Crop/OrganicFarming.shtml

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Glossary

Abiotic disease. A condition caused by nonliving, nonparasitic, or noninfectious agents.

Abscission. The dropping of leaves, flowers, or fruit by a plant. Can result from natural growth processes (e.g., fruit ripening) or from external factors such as temperature or chemicals.

Abscission layer. Specialized cells, usually at the base of a leaf stalk or fruit stem, that trigger both the separation of the leaf or fruit and the development of scar tissue to protect the plant.

Absorption. The intake of water and other materials through root or leaf cells.

Accumulated heat units. Number of heat units in a growing season. Usually calculated at temperatures above 50°F, but can be calculated at other temperatures, depending on the crop. A day's heat units are calculated as

$$\frac{\text{Max temp(°F)+Min temp(°F)}}{2} - 50°\text{F}$$

Acid soil. Soil with pH below 7 on a pH scale of 1 to 14. The lower the pH, the more acid the soil. (See also pH.)

Active ingredient. The chemical in a pesticide formulation that actually kills the target pest.

Additive. A substance that, when added to a pesticide, reduces the surface tension between two unlike materials (e.g., spray droplets and a plant surface), thus improving adherence. Also called an adjuvant or surfactant.

Adjuvant. See Additive.

Adventitious. Growth not ordinarily expected, usually the result of stress or injury. A plant's normal growth comes from meristematic tissue, but adventitious growth starts from nonmeristematic tissue.

Adventitious bud. A bud that develops in locations where buds usually do not occur. An example would be buds found on root pieces used for propagation; roots do not have buds.

Adventitious root. A root that forms at any place on the plant other than the primary root system.

Aeration. The practice involving removal of cores or turf plugs and soil with the purpose of reducing compaction and improving air flow.

Aerial root. An unusual type of root that develops on stems above ground.

Aerobic. Active in the presence of free oxygen.

After-ripening. The seed maturation process that must be completed before germination can occur.

Aggregation. The process by which individual particles of sand, silt, and clay cluster and bind together to form soil peds.

Agriculture. The study of plants in relation to field crop production.

Agronomy. The science of crop management, including the study of soils.

Alkaline soil. Soil with pH above 7 on a pH scale of 1 to 14. The higher the reading, the more alkaline the soil. (See also pH.)

Allelopathy. The excretion by some plants' leaves and roots of compounds that inhibit the growth of other plants.

Alternate leaf arrangement. Leaves are attached at alternating points from one side of the stem to the other.

Ammonium. A plant-available form of nitrogen contained in many fertilizers and generated in the soil by the breakdown of organic matter. (See also Nitrogen cycle.)

Anaerobic. Active in the absence of free oxygen.

Analogous. In landscaping, use of adjacent colors on the color wheel such as blue, violet, and red.

Anatomy. The study of plant structure.

Angiosperm. Flowering plants. Plants that have a highly evolved reproductive system. Seeds enclosed in an ovary such as a fruit, grain, or pod.

Anion. Negatively charged ion, for example, chloride.

Anion exchange. The interaction of anions on the surface of an active material with those in solution.

Anion exchange capacity (AEC). The sum total of exchangeable anions that a soil can absorb expressed in meq/100 g (milliequivalents per 100 grams) soil.

Annual. Plants that grow, mature, flower, produce seed, and die in one season.

Anoplura. A major order of insects that have two pairs of wings, or are wingless, and piercing-sucking mouthparts (sucking lice).

Anther. The pollen-bearing part of a flower's male sexual organ. The filament supports the anther; together they are referred to as the stamen.

Anthracnose. Plant disease characterized by black or brown dead areas on leaves, stems, or fruits.

Anvil pruner. A pruning tool that cuts a branch between one sharpened blade and a flat, anvil-shaped piece of metal. Has a tendency to crush rather than make a smooth cut.

Apex. The tip of a stem or root.

Apical dominance. The inhibition of lateral bud growth by the presence of the hormone auxin in a plant's terminal bud. Removing the growing tip removes auxin and promotes lateral bud break and subsequent branching, usually directly below the cut.

Apical meristem. Area of the plant shoot and root tips where cells actively divide to provide more cells that will expand and develop into the tissues and organs of the plant. Also called shoot meristem.

Arboretum. An area devoted to specimen plantings of trees and shrubs.

Asexual propagation. See Vegetative propagation.

Aspect. Direction of exposure to sunlight.

Assimilation. Building of cell matter from inorganic (minerals) and organic materials (carbohydrates and sugars).

Attractant. A material that lures pests.

Auxin. One of the best known and most important plant hormones. Most abundantly produced in a plant's actively growing tips. Generally stimulates growth by cell division in the tip region and by cell elongation lower down the shoot. Growth of lateral buds is strongly inhibited by the normal concentration of auxin in the growing tip.

Available water supply. Soil water that is available for plant uptake. Excludes water bound tightly to soil particles.

Axil. The upper angle formed by a leaf stalk (petiole) and the internodes above it on a stem.

Axillary bud. An undeveloped shoot or flower that is found at the node. Also called the lateral bud.

***Bacillus thuringiensis*.** A bacterium used as a biological control agent for many insects pests.

Bacterium. A single-celled, microscopic organism having a cell wall but no chlorophyll. Reproduces by cell division.

Balled and burlapped. A plant dug with soil. The root ball is enclosed with burlap or a synthetic material.

Band. To apply a pesticide or fertilizer in a strip over or along each crop row.

Bare-root. A plant with little or no soil around its roots; deciduous plants and small evergreens are commonly sold bare-root.

Basal. (1) At or near the base of a branch or trunk. (2) At or near a plant's crown.

Basal break. New growth that develops at the base of a branch or near a plant's crown.

Beneficial fungi. Fungi used in controlling organisms that attack desirable plants.

Beneficial insect. An insect that helps gardening efforts. May pollinate flowers, eat harmful insects or parasitize them, or break down plant material in the soil, thereby releasing its nutrients. Some insects are both harmful and benefi-

cial. For example, butterflies can be pollinators in their adult form but destructive in their larval (caterpillar) form.

Berry. The fleshy fruit of cane fruits, bush fruits, and strawberries.

Biennial. Plants that take two years, or a part of two years, to complete their life cycle.

Biennial bearing. Producing fruit in alternate years.

Binomial. A biological species name consisting of two names: the genus name and specific epithet.

Biological insect control. The use of beneficial organisms to control pest insect populations.

Biosolids. A by-product of wastewater treatment sometimes used as a fertilizer, also known as municipal sewage sludge.

Blackleg. Darkening at the base of a stem.

Blade. The flat thin part of a leaf.

Blanch. To exclude light from plants or parts of plants to render them white or tender. Often done to cauliflower, endive, celery, and leeks. Also used to promote adventitious root formation on stems.

Blight. Rapid death of leaves and other plant parts.

Blotch. A blot or spot (usually superficial and irregular in shape) on leaves, shoots, or fruit.

Bole. See Trunk.

Bolting. Producing seed or flowering prematurely, usually due to heat. For example, cool-weather crops such as lettuce bolt during summer; leaf crops are discouraged from bolting by removal of flower heads. (See also Deadhead.)

Bonsai. One of the fine arts of horticulture; growing carefully trained, dwarfed plants in containers selected to harmonize with the plants. Branches are pruned and roots trimmed to create the desired effect.

Botanical insecticide. An insecticide, such as rotenone or pyrethrum, derived from a plant. Most botanicals biodegrade quickly. Most, but not all, have low toxicity to mammals.

Botanical maturity. In fruits, refers to a final stage of development when the fruit is still on the plant and cell enlargement and the accumulation of carbohydrates and other flavor constituents are complete.

Botany. The science that studies all phases of plant life and growth.

Botrytis. A fungal disease promoted by cool, moist weather. Also known as gray mold or fruit rot.

Bract. A modified leaf, usually small, but sometimes large and brightly colored, growing at the base of a flower or on its stalk. Clearly seen on dogwoods and poinsettias.

Bramble. A spiny cane bush with berry fruits (e.g., raspberries and blackberries).

Branch. A subsidiary stem arising from a plant's main stem or from another branch.

Break. (1) Any new growth coming from a bud. (2) See Bud break.

Broadcast. (1) To sow seed by scattering it over the soil surface. (2) To apply a pesticide or fertilizer uniformly to an entire, specific area by scattering or spraying it.

Broadleaf evergreen. A non-needled evergreen.

Brown rot. Soft rot of fruit covered by gray to brown mold.

BTU. British thermal unit. Amount of heat required to raise the temperature of 1 pound of water 1°F.

Bud. A small protuberance on a stem or branch, sometimes enclosed in protective scales, containing an undeveloped shoot, leaf, or flower.

Bud break. The resumption of growth by resting buds.

Budding. A method of asexual plant propagation that unites one bud (attached to a small piece of bark) from the scion to the rootstock.

Bud head. A swollen or enlarged area where a bud was grafted to a stock.

Bud scale. A modified leaf that forms a protective covering for a bud.

Bud sport. See Mutation.

Bud stick. A shoot or twig used as a source of buds for budding.

Bud union. The suture line where a bud or scion was grafted to a stock. Sometimes called a graft union.

Bulb. A belowground stem (for example, in tulip) that is surrounded by fleshy scalelike leaves that contain stored food.

Bulbil. A small bulblike organ that sometimes forms on aerial plant parts.

Bulblet. (1) An underground bulb formed in the leaf axis on a stem. (2) A tiny bulb produced at the base of a mother bulb.

Calcium carbonate. A compound found in limestone, ashes, bones, and shells; the primary component of lime.

Callus. Tissue that forms over the wounds on plants.

Calorie. Amount of heat required to raise the temperature of 1 cubic centimeter of water 1°C.

Calyx. The entire set of sepals on a flower.

Cambium. A layer of meristematic tissue that produces new phloem on the outside, new xylem on the inside, and is the origin of all secondary growth in plants. The cambium layer forms the annual ring in wood.

Candelabrum. A strong, dominant rose cane with accelerated growth that originates from a bud union and explodes with many blooms.

Candle. On a pine tree, new terminal growth from which needles emerge.

Cane. The externally woody, internally pithy stem of a bramble or vine.

Canker. Sunken, discolored, dead areas on twigs or branches, usually starting from an injury, wound, or pathogen.

Canopy. (1) The top branches and foliage of a plant. (2) The shape-producing structure of a tree or shrub.

Capillary action. The force by which water molecules bind to the surfaces of soil particles and to each other, thus holding water in fine pores against the force of gravity.

Capitulum. (1) A dense, short, compact cluster of sessile flowers, as in composite plants or clover. (2) A very dense grouping of flower buds, as in broccoli.

Caterpillar. See Larva.

Catfacing. Disfigurement or malformation of a fruit. Fruits typically affected include tomatoes and strawberries. Catfacing is caused by insects or adverse weather during fruit development, as well as other unknown factors.

Cation. Positively charged ion. Plant nutrient examples include calcium and potassium. (See also Anion.)

Cation exchange capacity (CEC). A soil's capacity to hold cations as a storehouse of reserve nutrients.

Cell. A structural, functional unit of a plant.

Central leader. (1) A trunk or stem extending up through the axis of a tree or shrub and clearly emerging at the top. (2) A system of pruning that uses the central leader as a basic component. (See also leader.)

Cercus. A threadlike or sometimes forcepslike tail near the tip of an insect's abdomen (usually a pair). Plural = cerci.

Chelate. A complex organic substance that holds micronutrients, usually iron, in a form available for absorption by plants.

Chemical insect control. The use of chemicals, or insecticide, to control insect populations.

Chlorophyll. The green pigment in plants responsible for trapping light energy for photosynthesis.

Chloroplast. A specialized component of certain cells. Contains chlorophyll and is responsible for photosynthesis.

Chlorosis. Yellowing or whitening of normally green tissue.

Clay. The smallest type of soil particle (less than 0.002 mm in diameter).

Climber. A plant that climbs on its own by twining or using gripping pads, tendrils, or some other method to attach itself to a structure or another plant. Plants that must be trained to a support are properly called trailing plants, not climbers.

Cloche. A plastic, glass, or Plexiglas plant cover used to warm the growing environment and protect plants from frost.

Clone. A plant group whose members have all been derived from a single individual through constant propagation by vegetative (asexual) means, e.g., by buds, bulbs, grafts, cuttings, or laboratory tissue culture.

C:N ratio. The ratio of carbon to nitrogen in organic materials. Materials with a high C:N ratio (high in carbon) are good bulking agents in compost piles, while those with a low C:N ratio (high in nitrogen) are good energy sources.

Cold composting. A slow composting process that involves simply building a pile and leaving it until it decomposes. This process may take months or longer. Cold composting does not kill weed seeds or pathogens.

Cold frame. A plastic-, glass-, or Plexiglas-covered frame or box that relies on sunlight as a source of heat to warm the growing environment for tender plants.

Cole crops. A group of vegetables belonging to the cabbage family; plants of the genus *Brassica*, including cauliflower, broccoli, cabbage, turnips, and Brussels sprouts.

Coleoptera. A major order of insects that have two pairs of wings, or are wingless, and chewing mouthparts (beetles, weevils).

Collar. A swollen area at the base of a branch where it connects to a trunk. Contains special tissue that prevents decay from moving downward from the branch into the trunk. (See also Shoulder ring.)

Collembola. A major order of insects that are wingless and have chewing mouthparts (springtails).

Compaction. Pressure that squeezes soil into layers that resist root penetration and water movement. Often the result of foot or machine traffic.

Companion planting. The practice of growing two or more types of plants in combination to discourage disease and insect pests.

Compatible. Different varieties or species that set fruit when cross-pollinated or that make a successful graft union when intergrafted. (See also Pollenizer.)

Complementary. In landscaping, use of opposite colors on the color wheel such as red and green, orange and blue, and yellow and violet.

Complete fertilizer. A fertilizer that contains all three macronutrients (N, P, K).

Complete metamorphosis. A type of insect development in which the insect passes through the stages of egg, larva, pupa, and adult. The larva usually is different in form from the adult. (See also Simple metamorphosis.)

Compost. The product created by the breakdown of organic waste under conditions manipulated by humans. Used to improve both the texture and fertility of garden soil. (See also Humus.)

Compound bud. More than one bud on the same side of a node. Usually, unless growth is extremely vigorous, only one of the buds develops, and its branch may have a very sharp angle of attachment. If it is removed, a wider angled shoot usually is formed from the second (accessory) bud. Ashes and walnuts are examples of plants that typically have compound buds.

Conifer. A cone-bearing tree or shrub, usually evergreen. Pine, spruce, fir, cedar, yew, and juniper are examples.

Conk. A fungal fruiting structure (e.g., shelf or bracket fungi) formed on rotting woody plants.

Cordon. (1) A method of espaliering fruit trees, vines, etc., to horizontal, vertical, or angled wire or wooden supports so the maximum branch surface is exposed to the sun, resulting in maximum fruit production. (2) A branch attached to such a support.

Cork cambium. On woody plants, the layer of cells that produces bark, or cork, located just below the bark layers.

Corm. A belowground stem that is swollen (for example, in crocus).

Cormel. A small, underdeveloped corm, usually attached to a larger corm.

Cornicle. A short, blunt horn or tube (sometimes buttonlike) on the top and near the end of an aphid's abdomen. Emits a waxy liquid that helps protect against enemies.

Corolla. Part of a flower; all of the petals together.

Cortex cells. Found beneath the epidermis, these cells help move water from the epidermis and are active in food storage.

Corymb. A usually flat-topped flower cluster in which the individual flower stalks grow upward from various points on the main stem to approximately the same level.

Cotyledon. A seed leaf, the first leaf from a sprouting seed. Monocots have one cotyledon, dicots have two.

Cover crop. (1) A crop planted to protect the soil from erosion. (2) A crop planted to improve soil structure or organic matter content.

Crop rotation. The practice of growing different types of crops in succession on the same land chiefly to preserve the productive capacity of the soil by easing insect, disease, and weed problems.

Cross-pollination. The fertilization of an ovary on one plant with pollen from another plant, producing an offspring with a genetic makeup distinctly different from that of either parent. (See also Pollenizer.)

Crotch angle. The angle formed between a trunk and a main scaffold limb. The strongest angles are 45° to 60°.

Crown. (1) Collectively, the branches and foliage of a tree or shrub. (2) The thickened base of a plant's stem or trunk to which the roots are attached. (3) Compressed aboveground stems as occurs in grasses.

Crown gall. A specific disease caused by the bacterium *Agrobacterium tumefaciens* that causes excessive, undifferentiated growth that may girdle roots, stems, or branches.

Cultivar. Contraction of cultivated variety. Propagation of cultivars results in little or no genetic change in the offspring, which preserves desirable characteristics.

Cultural insect control. Controlling an insect population by maintaining good plant health and by crop rotation and/or companion crops.

Curlytop. Rolling and curling of leaves at the growing point. May be indicative of viral infection.

Cuticle. (1) A waxy layer on the epidermis on a leaf. (2) The outer layer of an insect's body.

Cutin. (1) A waxy substance on plant surfaces that tends to make the surface waterproof and can protect leaves from dehydration and disease. (2) A waxy substance on an insect's cuticle that protects the insect from dehydration.

Cutting. One of several forms of asexual propagation.

Cyme. A flower stalk on which the florets start blooming from the top of the stem and progress toward the bottom.

Cyst. The swollen, egg-containing female body of certain nematodes. Can sometimes be seen on the outside of infected roots.

Damping off. Stem rot near the soil surface leading to either failed seed emergence or to the plant's falling over after emergence.

Day-neutral plant. A cultivar or species capable of flowering without regard to day length. (See also Short-day plant, Long-day plant.)

Deadhead. To remove individual, spent flowers from a plant for the purpose of preventing senescence and prolonging blooming. For effective results, the ovary behind the flower must be removed as well.

Deciduous. A plant that sheds all of its leaves annually.

Decomposers. The microorganisms and invertebrates that accomplish composting.

Decomposition. The breakdown of organic materials by microorganisms.

Defoliation. The unnatural loss of a plant's leaves, generally to the detriment of its health. Can be caused by several factors such as high wind, excessive heat, drought, frost, chemicals, insects, or disease.

Dehorning. A drastic method of pruning a neglected tree or shrub. Entails the removal of large branches, especially high in the crown, a few at a time over several seasons.

Dermaptera. A major order of insects that have two pairs of wings, or are wingless, and have mouthparts (earwigs).

Desiccation. Drying out of tissue.

Determinate. A plant growth habit in which stems stop growing at a certain height and produce a flower cluster at the tip. Determinate tomatoes, for example, are short, early fruiting, have concentrated fruit set, and may not require staking. (See also Indeterminate.)

Dethatch. To remove thatch (a tightly intermingled layer of stems and roots, living and dead, that forms between the soil surface and green vegetation of grass).

Diatomaceous earth. The fossilized remains of diatoms (a type of tiny algae) used to kill insect pests, snails, and slugs.

Dicot. See Dicotyledon.

Dicotyledon. Plants with two seed leaves. Also referred to as dicot.

Dieback. Progressive death of shoots, branches, or roots, generally starting at the tips.

Differentiation. A change in composition, structure, and function of cells and tissues during growth.

Dioecious. Plants that have male and female flowers occurring on separate plants (e.g., holly).

Diptera. A major order of insects that have one pair of wings and sucking or siphoning mouthparts as adults and chewing mouthparts as larvae (mosquitoes, flies, and gnats).

Disbud. The selective removal of some flower buds so remaining buds receive more of the plant's energy and produce larger, showier flowers. Roses, chrysanthemums, and camellias often are disbudded.

Division. The breaking or cutting apart of a plant's crown for the purpose of producing additional plants, all genetically identical to the parent plant.

DNA. Deoxyribonucleic acid is the genetic information that dictates all cellular processes. DNA is organized into chromosomes and is responsible for all characteristics of the plant.

Dormancy. The annual period when a plant's growth processes greatly slow down.

Dormant. Resting or not growing. A deciduous tree is dormant in the winter.

Dormant bud. A bud formed during a growing season that remains at rest during the following winter or dry season. If it does not expand during the following growing season, it is termed latent.

Dormant oil. An oil applied during the dormant season to control insect pests and diseases.

Double, semidouble. A flower with more than the normal number of petals, sepals, bracts, or florets. May be designated botanically by the terms flore pleno, plena or pleniflora.

Double worked. Grafted twice, i.e., grafted to an intermediate stock.

Drainage. The ability of soil to transmit water through the surface and subsoil.

Dripline. An imaginary line on the ground directly beneath the outermost tips of a plant's foliage. Rain tends to drip from leaves onto this line.

Drip zone. The area from the trunk of a tree or shrub to the edge of its canopy. Most, but not all, of a plant's feeder roots are located within this area.

Drupe fruit. See Stone fruit.

Dwarfed. Restricted plant size without loss of health and vigor.

Ecology, plant. The study of the complex relationships of plants in biological communities.

Economic threshold. The level at which pest damage justifies the cost of control. In home gardening, the threshold may be aesthetic rather than economic.

Emasculate. To remove a flower's anthers.

Embryo. The tiny plant that is formed inside a seed during fertilization. It has two growing points, the radicle (a tiny root) and the plumule (a tiny shoot).

Embryo dormancy. Common in seed of woody perennial plants. A physiological condition in the embryo that prevents it from growing. This type of dormancy can be overcome by stratification.

Enation. Epidermal outgrowths on leaves or stems.

Endoskeleton. The internal body support found in most animals outside of the insect kingdom.

Endosperm. The food-storage area in a seed that feeds the embryo.

Enzyme. A biological catalyst that aids in conversion of food and other chemical structures from one form to another.

Epidemic. A widespread and severe outbreak of a disease.

Epidermis (leaf). The outer cell layers on the top and bottom of the leaf.

Epidermis (root). The cells that protect the root surface. The epidermis contains the root hairs and is responsible for the absorption of water and minerals dissolved in water.

Epidermis (stem). In nonwoody plants, the outer single layer of surface cells that protects the stem. As in leaves, this layer is usually cutinized, or waxy, and on young stems it has stomata.

Epinasty. An abnormal downward-curving growth or movement of a leaf, leaf part, or stem.

Espalier. The training of tree or shrub to grow flat on a trellis or wall. Espalier patterns may be very precise and formal or more natural and informal.

Etioliation. Long internodes and pale green color of plants growing under insufficient light or in complete darkness.

Evergreen. A plant that never loses all its foliage at the same time.

Excise. To remove or extract, as an embryo from a seed or ovule.

Excurrent. A tree form in which the main trunk remains dominant with small more or less horizontal branches. Fir and sweetgum are examples.

Exfoliating. Peeling off in shreds or thin layers, as in bark from a tree.

Exoskeleton. An insect's outer body support.

Exotic. Non-native.

Fallow. To keep land unplanted during one or more growing seasons.

Family. A sub-order in the classification of plants.

Fasciation. Distortion of a plant that results in thin, flattened, and sometimes curved shoots.

Feeder roots. Fine roots and root branches with a large absorbing area (root hairs.) Responsible for taking up the majority of a plant's water and nutrients from the soil.

Fertility (soil). The presence of minerals necessary for plant life.

Fertilization. (1) The fusion of male and female germ cells following pollination. (2) The addition of plant nutrients to the environment around a plant.

Fertilizer. Any substance added to the soil (or sprayed on plants) to supply those elements required in plant nutrition.

Fertilizer analysis. The amount of nitrogen, phosphorus (as P_2O_5), and potassium (as K_2O) in a fertilizer expressed as a percentage of total fertilizer weight. Nitrogen (N) is always listed first, phosphorus (P) second, and potassium (K) third.

Fertilizer ratio. The smallest whole number relationship among N, P_2O_5, and K_2O.

Fibrous root. A root system that branches in all directions, often directly from the plant's crown, rather than branching in a hierarchical fashion from a central root. (See also Taproot.)

Filament. The stalk supporting a flower's anthers.

Flagging. Loss of turgor and drooping of plant parts, usually as a result of water stress.

Floating row covers. Covers, usually of a clothlike material, placed over growing plants and used to protect the plants growing beneath from undesirable pests and climate.

Floricane. Second-year growth of cane berries. Produces fruit on laterals.

Flower bud. A type of bud that produces one or more flowers.

Foliar fertilization/feeding. Fertilization of a plant by applying diluted soluble fertilizer, such as fish emulsion or kelp, directly to the leaves.

Force. To bring a plant into early growth, generally by raising the temperature or transplanting it to a warmer situation. Tulips and paper whites are examples of plants that often are forced.

Form. (1) A naturally occurring characteristic different from other plants in the same population. (2) The growth habit (shape) of a plant.

Formal. (1) A garden that is laid out in precise symmetrical patterns. (2) A flower, such as some camellias, that consists of layers of regularly overlapping petals.

Frond. Specifically, the foliage of ferns, but often applied to any foliage that looks fernlike, such as palm leaves.

Fruit. The enlarged ovary that develops after fertilization occurs.

Fruiting habit. The location and manner in which fruit is borne on woody plants.

Fumigation. The application of a toxic gas or other volatile substance to disinfect soil or a container, such as a grain bin.

Fungicide. A compound toxic to fungi.

Fungus. A plant organism that lacks chlorophyll, reproduces via spores, and usually has filamentous growth. Examples are molds, yeasts, and mushrooms.

Gall. A growth on plant stems or leaves caused by abnormal cell growth stimulated by the feeding of some insects (e.g., aphids) or by viral, fungal, or bacterial infection or genetic abnormality.

Genus. A subdivision of family in the classification of plants. Plants of the same genus share similarities mostly in flower characteristics and genetics. Plants in one genus usually cannot breed with plants of another genus.

Genetically modified. A plant or animal that has had genetic material introduced to its genome from other organisms through artificial means.

Geography, plant. The study of the distribution of plants throughout the world.

Geotropism. The turning or curving of a plant's parts in response to gravity. A root growing downward is an example. Geotropism is controlled largely by the hormone auxin.

Germination. The processes that begin after planting a seed that lead to the growth of a new plant.

Girdling. The damaging, cutting, removing, or clamping of cambium all the way around a trunk or branch. Sometimes, girdling is done deliberately to kill an unwanted tree, but often it results from feeding by insects or rodents. Wires and ties used to support a tree can cause girdling, as can string trimmers.

Glabrous. Hairless, but not necessarily smooth.

Glaucous. Covered with a grayish, bluish, or whitish waxy coating that is easily rubbed off. Blue spruce needles are an example of glaucous leaves.

Gradual metamorphosis. See Simple metamorphosis.

Graft union. See Bud union.

Grafting. A method of asexual plant propagation that joins plant parts so they will grow as one plant.

Gravitational water. Water in excess of a soil's capacity. Drains downward to groundwater.

Green cone. An enclosed composting unit often used for composting food waste.

Green manure. An herbaceous crop plowed under while green to enrich the soil.

Groundcover. Plants used for holding soil, controlling weeds, and providing leaf texture.

Growing season. The period between the beginning of growth in the spring and the cessation of growth in the fall.

Growth regulator. A compound applied to a plant to alter its growth in a specific way. May be a natural or synthetic substance. (See also Hormone.)

Guard cells. Cells on either side of each stoma. They swell to open the stoma and shrink to close it.

Gymnosperm. Plants that have seed not enclosed in an ovary (e.g., conifers).

Haltere. A small, knoblike organ (sometimes shaped like a baseball bat or bowling pin) located on the thorax of insects of the order Diptera. Takes the place of hindwings and helps balance the insect in flight.

Hardening off. (1) The process of gradually exposing seedlings started indoors to outdoor conditions before transplanting. (2) The process of gradual preparation for winter weather.

Hardpan. An impervious layer of soil or rock that prevents root growth and downward drainage of water.

Hardy. Frost or freeze tolerant. In horticulture, this term does not mean tough or resistant to insect pests or disease.

Haustorium. A modified hyphal branch of a parasitic plant. Grows into a host plant's cell to absorb food and water.

Head. (1) To cut off part of a shoot or limb rather than remove it completely at a branch point. (2) The part of a tree from which the main scaffold limbs originate.

Heartwood. The central cylinder, often dark colored, of xylem tissue in a woody stem.

Heeling in. The temporary burying of a newly dug plant's roots to prevent their drying until a new planting site is prepared. Nurseries heel in bareroot berries, trees, and shrubs.

Hemiptera. A major order of insects that have two pairs of wings and piercing-sucking mouthparts (bed bugs, stink bugs, cinch bugs).

Herbaceous. A soft, pliable, usually barkless shoot or plant. Distinct from stiff, woody growth.

Herbaceous perennial. A plant that dies back in the winter and regrows from the crown in spring.

Herbicide. A chemical used to kill undesirable plants.

Heterozygous. Having mixed hereditary factors, not a pure line.

Homoptera. A major order of insects that have two pairs of wings, or are wingless, and piercing-sucking mouthparts (aphids, leafhoppers, scales, mealybugs).

Homozygous. Having purity of type, a pure line.

Honeydew. A sticky substance excreted by aphids and some other insects.

Hormone. A naturally occurring compound that alters plant growth in a specific manner. (See also Growth regulator.)

Horticultural oil. An oil made from petroleum products, vegetable oil, or fish oil used to control insect pests and diseases. Oils work by smothering insects and their eggs and by protectively coating buds against pathogen entry.

Horticulture. The science of growing fruits, vegetables, flowers, and other ornamental plants.

Host. A plant on which an insect or disease completes all or part of its life cycle.

Host plant. A plant that is invaded by a parasite.

Host range. The various plants that may be attacked by a parasite.

Hotbed. An enclosed bed for propagating or protecting plants. Has a source of heat to supplement solar energy.

Hot composting. A fast composting process that produces finished compost in 4 to 8 weeks. High temperatures are maintained by mixing balanced volumes of energy materials and bulking agents, by keeping the pile moist, and by turning it frequently to keep it aerated.

Humus. The end product of decomposing animal or vegetable matter. (See also Compost.)

Hybrid. The results of a cross between two different species or well-marked varieties within a species. Hybrids grown in a garden situation will not breed true to form from their own seed.

Hydroponics. A method of growing plants without soil. Plants usually are suspended in water or polymers, and plant nutrients are supplied in dilute solutions.

Hymenoptera. A major order of insects that have two pairs of wings, or are wingless, and chewing mouthparts (wasps, bees, ants, sawflies).

Hypha. A single filament of a fungus.

Hypocotyl. The seedling stem that develops below the cotyledons.

Imbibition. The portion of the germination process that involves the absorption of water, causing the seed to swell, and that triggers cell enzyme activity, growth, and the bursting of the seed coat.

Immobilization. The process by which soil microorganisms use available nitrogen as they break down materials with a high C:N ratio, thus reducing the amount of nitrogen available to plants.

Immune. A plant that does not become diseased by a specific pathogen. (See also Resistant, Tolerant.)

Imperfect flower. Flowers lacking one or more of the sexual parts.

Incompatible. Kinds or varieties of a species that do not successfully cross pollinate or intergraft.

Incomplete flower. A type of flower that lacks one or more of the four parts: pistil, stamen, sepals, or petals.

Incomplete metamorphosis. See Simple metamorphosis.

Incubation. A period of development during which a pathogen changes to a form that can penetrate or infect a new host plant.

Indeterminate. A plant growth habit in which stems keep growing in length indefinitely. For example, indeterminate tomatoes are tall, late-fruiting, and require staking for improved yield. (See also Determinate.)

Infection. The condition reached when a pathogen has invaded plant tissue and established a parasitic relationship between itself and its host.

Infiltration. The movement of water into soil.

Inflorescence. The arrangement of flowers on an axis or stem or a flower cluster.

Inflorescence collective. A group of individual flowers. The grouping can take many forms, such as a spike (flowers closely packed along a vertical stem, e.g., snapdragons), an umbel or corymb (flowers forming a flattened dome, e.g., yarrow), a panicle (a complex hierarchical arrangement of flowers, e.g., hydrangeas), or a capitulum (tightly packed disc flowers, e.g., the center of a daisy).

Inoculation. The introduction of a pathogen to a host plant's tissue.

Inoculum. Any part of the pathogen that can cause infection.

Inorganic. Being or composed of matter other than plant or animal.

Insectary plant. A plant that attracts beneficial insects.

Insecticidal soap. A specially formulated soap that is only minimally damaging to plants, but kills insects. Usually works by causing an insect's outer shell to crack, resulting in its interior organs drying out.

Insecticide. A chemical used to control, repel, suppress, or kill insects.

Instar. The stage of an insect's life between molts.

Integrated control. An approach that attempts to use several or all available methods for control of a pest or disease.

Integrated insect control. The use of a variety of insect control methods, beginning with simpler methods and progressing to include aspects from all types of control.

Integrated pest management. A method of managing pests that combines cultural, biological, mechanical, and chemical controls, while taking into account the impact of control methods on the environment.

Intensive gardening. The practice of maximizing use of garden space, for example by using trellises, intercropping, succession planting, and raised beds.

Intercalary meristem. Found mostly in monocots, these cells divide and provide the growth of the leaf from the base of the plant.

Intercropping/Interplanting. The practice of mixing plants to break up pure stands of a single crop.

Internode. The area of the stem that is between the nodes.

Interstem, interstock. The middle piece of a graft combination made up of more than two parts, i.e., the piece between the scion and the rootstock. Often has a dwarfing effect.

Invasive. Growing vigorously and outcompeting other plants in the same area; difficult to control.

Ion. An electrically charged particle. In soils, an ion refers to an electrically charged element or combination of elements resulting from the breaking up of an electrolyte in solution.

Isolation. The separation of a pathogen from its host by culturing on a nutrient medium or on an indicator plant.

Isoptera. A major order of insects that have two pairs of wings, or are wingless, and chewing mouthparts (termites).

Joint. A node; the place on a stem where a bud, leaf, or branch forms.

Juvenile stage. (1) The early or vegetative phase of plant growth characterized by the inability to flower. (2) The first stage of an insect's life cycle after the egg, either a larva or a nymph. (3) The immature stage of an organism.

K. See Potassium.

Key, dichotomous. A tool for plant or animal classification and identification. Consists of a series of paired statements that move from general to specific descriptions.

Knot garden. A formal garden in which two or more kinds of plants with different-colored foliage, often herbs, are planted and pruned so they interweave and form a knot pattern.

Larva. The immature form of an insect that undergoes complete metamorphosis. Different from the adult in form, a caterpillar for example.

Latent bud. Buds that do not grow for long periods of time and can become embedded in the enlarging stem tissue. These buds grow only when conditions necessary for their growth occur, such as drastic pruning. Not all plants have latent buds.

Lateral. A branch attached to and subordinate to another branch or trunk.

Lateral bud. An undeveloped shoot or flower that is found at the node. Also called the axillary bud.

Lateral meristem. Cylinders of actively dividing cells that start just below the apical meristem and are located up and down the plant. Also called the vascular cambium.

Layering. A method of stimulating adventitious roots to form on a stem. There are two primary methods of layering. In ground layering, a low-growing branch is bent to the ground and covered by soil. In air layering, moist rooting medium is wrapped around a node on an aboveground stem.

Leaching. Movement of water and soluble nutrients down through the soil profile.

Leader. A developing stem or trunk that is longer and more vigorous than the laterals. (See also Central leader.)

Leaf curl. Rolling and curling of leaves.

Leaflet. A single division of a compound leaf

Leaf scar. A visible, thickened crescent or line on a stem where a leaf was attached.

Lenticel. A small opening on the surface of fruits, stems, and roots that allows exchange of gases between internal tissues and the atmosphere.

Lepidoptera. A major order of insects that have two pairs of wings and sucking or siphoning mouthparts as adults and chewing mouthparts as larvae (moths, butterflies).

Lesion. A localized area of discolored or dead tissue.

Life cycle. The successive stages of growth and development of an organism.

Lime. A rock powder consisting primarily of calcium carbonate. Used to raise soil pH (decrease acidity).

Loam. A soil with roughly equal proportions of sand, silt, and clay particles.

Lodge. To fall over, usually due to rain or wind. Corn and tall grasses are examples of plants susceptible to lodging.

Long-day plant. A plant requiring more than 12 hours of continuous daylight to stimulate a change in growth, e.g., a shift from the vegetative to reproductive phase. (See also Short-day plant, Day-neutral plant.)

Macronutrient. Collectively, primary and secondary nutrients.

Macropore. A large soil pore. Macropores include earthworm and root channels and control a soil's permeability and aeration.

Mallophaga. A major order of insects that are wingless and have chewing mouthparts (chewing lice).

Mandible. The first pair of jaws on insects: stout and toothlike in chewing insects, needle or sword-shaped in sucking insects. The lateral (left and right) upper jaws of biting insects.

Maturity. (1) In fruit, ripeness, usually the state of development that results in maximum quality. (2) The flowering phase of plant growth.

Mechanical insect control. Manual removal of insects and eggs from infested plants

Meristem. Plant tissue in the process of formation; vegetative cells in a state of active division and growth, e.g., those at the apex of growing stems and roots and responsible for enlarging stem diameter.

Mesophyll. In between the epidermis layers, where photosynthesis occurs.

Metamorphosis. The process by which an insect develops. (See also Complete metamorphosis, Simple metamorphosis.)

Microclimate. Climate affected by landscape, structures, or other unique factors in a particular immediate area.

Micronutrient. A nutrient, usually in the parts per million range, used by plants in small amounts, less than 1 part per million (boron, chlorine, copper, iron, manganese, molybdenum, zinc, and nickel).

Micropore. A fine soil pore, typically a fraction of a millimeter in diameter. Micropores are responsible for a soil's ability to hold water.

Microscopic. Organisms so small that they can be seen only with the aid of a microscope.

Mixed buds. Buds that produce both shoots and flowers.

Mixed fertilizer. A fertilizer that contains at least two of the three macronutrients (N, P, K).

Modified central leader. A system of pruning used primarily on fruit trees. The central leader is encouraged for the first few years, then suppressed. This system allows for well-placed scaffolds and strong crotches, but keeps the tree's crown relatively close to the ground for easy harvesting.

Molt. The shedding of exoskeleton during insect growth. The form assumed between molts is called an instar.

Monochromatic. In landscaping, use of the various tints, shades, and hues of only one color.

Monocot. See Monocotyledon.

Monocotyledon. Plants with one seed leaf. Also referred to as monocot.

Monoecious. Plants that have imperfect flowers (male and female) occurring on the same plant (e.g., corn).

Morphology. The study of the origin and function of plant parts.

Mosaic. Nonuniform foliage coloration with a more or less distinct intermingling of normal green and light green or yellowish patches.

Mottle. An irregular pattern of light and dark areas.

Mulch. Any material placed on the soil surface to conserve soil moisture, moderate soil temperature, and/or control weeds. Wood chips, bark chips, and shredded leaves are mulches that eventually add organic matter to the soil; inorganic materials such as rocks are also used.

Mutation. A genetic change within an organism or its parts that changes its characteristics. Also called a bud sport or sport.

Mycelia. Masses of fungal threads (hyphae) that make up the vegetative body of a fungus.

Mycology. The study of fungi.

Mycoplasma. See Phytoplasma.

Mycorrhizae. Beneficial fungi that infect plant roots and increase their ability to take up nutrients from the soil.

N. See Nitrogen.

Native plant. A plant indigenous to a specific habitat or area.

Naturalize. (1) To design a garden with the aim of creating a natural scene. Planting generally is done randomly, and space is left for plants to spread at will. (2) The process whereby plants spread and fill in naturally.

Necrosis. Death of tissue.

Nectaries. Cells of the petal of a flower that secrete nectar.

Nematicide. A material that kills or protects against nematodes.

Nematode. Microscopic roundworms that live in soil and living tissue, as well as water, and survive as eggs or cysts.

Nitrate. A plant-available form of nitrogen contained in many fertilizers and generated in the soil by the breakdown of organic matter. Excess nitrate in soil can leach to groundwater. (See also Nitrogen cycle.)

Nitrifier. A microbe that converts ammonium to nitrate.

Nitrogen. A primary plant nutrient, especially important for foliage and stem growth.

Nitrogen cycle. The sequence of biochemical changes undergone by nitrogen as it moves from living organisms, to decomposing organic matter, to inorganic forms, and back to living organisms.

Nitrogen fixation. The conversion of atmospheric nitrogen into plant-available forms by rhizobia bacteria living on the roots of legumes.

Node. The area of the stem that bears a leaf or a branch. The joint of a stem.

Nomenclature. The assigning of names in the classification of plants.

Nonpoint source. A relatively small, nonspecific source of pollutants that, when added to other sources, may pose a significant threat to the environment. (See also Point source.)

Nonselective pesticide. A pesticide that kills most plants or animals.

Nonviable. Not alive; nonviable seeds may look normal but will not grow.

Noxious weed. (1) Weeds that have been declared by law to be a species having the potential to cause injury to public health, crops, livestock, land, or other property. (2) A very invasive, difficult to control plant.

N-P-K. Acronym for the three major plant nutrients contained in manure, compost, and fertilizers. N stand for nitrogen, P for phosphorus, and K for potassium.

Nucleus. The organelle within a cell that contains chromosomes and thus controls various cellular processes, including division into new cells.

Nutrient. Any substance, especially in the soil, that is essential for and promotes plant growth. (See also Macronutrient, Micronutrient.)

Nymph. The immature stage of an insect that undergoes simple metamorphosis. Usually similar in form to the adult.

Offset. A new shoot that forms at the base of a plant or in a leaf axil.

Oil. See Horticultural oil.

Open-pollinated seed. Seed produced from natural, random pollination so that the resulting plants are varied.

Opposite leaf arrangement. Two leaves are attached at the same point on the stem, but on opposite sides.

Organelle. A structure within a cell, such as a chloroplast, that performs a specific function.

Organic. (1) Relating to, derived from, or involving the use of food produced with the use of feed or fertilizer of plant or animal origin without employment of synthetically formulated fertilizers, growth stimulants, antibiotics, or pesticides. (2) Being or composed of plant or animal matter. (3) A labeling term that refers to an agricultural product produced in accordance with government standards.

Organic fertilizer. A natural fertilizer material that has undergone little or no processing. Can include plant, animal, and/or mineral materials.

Organic matter. Any material originating from a living organism (peat moss, plant residue, compost, ground bark, manure, etc.).

Organic pesticide. Pesticides derived from plant or animal sources.

Organic production. The production of food using accepted naturally occurring materials.

Organism. A living being.

Ornamental plant. A plant grown for beautification, screening, accent, specimen, color, or other aesthetic reasons.

Orthoptera. A major order of insects that have two pairs of wings, or are wingless, and chewing mouthparts (grasshoppers, crickets, and cockroaches).

Osmosis. Passage of materials through a membrane from an area of high concentration to an area of lower concentration.

Outer seed coat. The protective outer shell for the seed.

Ovary. The part of a flower containing ovules that will develop into seeds upon fertilization. Along with the style and stigma, it makes up the pistil (female sexual organ).

Ovule. Within the ovary, a tissue/structure that will develop into a seed after fertilization.

Oxidative respiration. The chemical process by which sugars and starches are converted to energy. In plants, known as respiration.

P. See Phosphorus.

Palisade mesophyll. The cells just beneath a leaf's upper epidermis that contain most of the leaf's

chlorophyll and that are responsible for most photosynthesis.

Palmate. (1) A leaf whose veins radiate outward from a single point somewhat like the fingers of a hand. (2) A form of espalier training.

Parasite. An organism that lives in or on another organism (host) and derives its food from the latter.

Parasitic seed plant. A plant that lives parasitically on other seed plants. An example is mistletoe.

Parterre. A formal garden in which shrubs, flowers, and paths form a geometric pattern of matched pairs.

Parthenocarpic. Development of fruit without fertilization.

Pathogen. Any organism that can cause a disease.

Pathology. The study of plant diseases.

Ped. A cluster of individual soil particles.

Pedicel. The stem of an individual flower.

Peduncle. The main stem supporting a cluster of flowers (as opposed to a pedicel, which is the stem of an individual flower).

Pendulous. More or less hanging or declined.

Perennial. A plant that lives more than two years and produces new foliage, flowers, and seeds each growing season.

Perfect flower. A type of flower with both stamens and pistils.

Perianth. Collectively, sepals and petals form the perianth.

Permanent wilting point. The point at which a wilted plant can no longer recover.

Permeability. The rate at which water moves through a soil.

Persistent. (1) Adhering to a position instead of falling, whether dead or alive, e.g., flowers or leaves. (2) A pesticide that retains its chemical properties in the soil for a long time.

Petals. Part of a flower, the floral structure inside the sepals, often brightly colored.

Petiole. The stalk of a leaf.

pH. The acidity or alkalinity of a solution on a scale of 0-14, with a value of 7 signifying neutral, values below 7 signifying acidic, and values above 7 signifying alkaline. Relates to the concentrations of hydrogen (H^+) ions in the soil. pH values are logarithmic.

Phenological stage. Crop development stage.

Pheromone. A vapor or liquid emitted by an insect that causes a specific response from a receiving insect. Some pheromones are used to find a mate. Synthetic pheromones are used as attractants in insect traps.

Phloem. The principle nutrient-conducting structure of vascular plants.

Phosphate. The form of phosphorus listed in most fertilizer analyses.

Phosphorus (P). A primary plant nutrient, especially important for flower production. In fertilizer, usually expressed as phosphate.

Photoperiod. The amount of time a plant is exposed to light.

Photosynthate. A food product (sugar or starch) created through photosynthesis.

Photosynthesis. Formation of carbohydrates from carbon dioxide and a source of hydrogen (as water) in the chlorophyll-containing tissues of plants exposed to light.

Phototropism. The phenomenon of plants growing toward the direction of a light source.

Physiology. The study dealing with the functioning of plants, their mechanisms of response, and their physical and biochemical processes.

Phytoplasm. Microscopic, single-celled organisms that lack distinct cell walls and that cause destructive diseases in plants.

Phytotoxic. Toxic to a plant.

Picotee. A pattern of flower petal coloration in which the edges of the petal are in a color that contrasts with the flower body.

Pinch. To remove a growing tip from a stem, thus causing axillary shoots or buds to develop. (See also Deadhead, Shear.)

Pistil. The female component of the flower. It is in the center of the flower and has three parts, the stigma, the style, and the ovary.

Pistillate. Female flowers; flowers with no stamens (pistils only), also called imperfect because they lack the stamen.

Plant classification. The scientific grouping and naming of plants by characteristics.

Plant disease. Any lasting change in a plant's normal structure or function that deviates from its healthy state.

Plant growth regulator. See Growth regulator.

Plant nutrition. A plant's need for and use of basic chemical elements. (See also Macronutrient, Micronutrient.)

Plant pathology. The study of diseases in plants: what causes them, what factors influence their development and spread, and how to prevent or control them.

Plant tissue culture. Plant material grown *in vitro* under sterile conditions in an artificial medium. A primary means of rapidly increasing the number of plants from a single mother plant.

Pleach. To intertwine branches of trees, vines, or shrubs to form an arbor or hedge.

Pleniflora. A term used in botanical names to indicate a double-flowered cultivar. (See also Double.)

Plumule. The shoot portion of an embryo.

Point source. A single, identifiable source of pollutants such as a factory or municipal sewage system. (See also Nonpoint source.)

Pollard. A method of tree pruning that involves heading back severely to main branches each year so as to produce a thick, close growth of young branches.

Pollen. A plant's male sex cells, which are held on the anther for transfer to a stigma by insects, wind, or some other mechanism.

Pollenizer. A plant whose pollen sets fruit on another plant. (See also Cross-pollination.)

Pollen tube. A slender tube growing from the pollen grain that carries the male gametes and delivers them to the ovary.

Pollination. The first step in fertilization; the transfer of pollen from anther to a stigma.

Pollinator. An agent such as an insect that transfers pollen from a male anther to a female stigma.

Polychromatic. In landscaping, use of all the colors and their tints, shades, and tones.

Pome fruit. A fruit having a core, such as an apple, pear, or quince.

Pomology. The science of fruits and the art of fruit culture, especially tree fruits.

Postemergent. A product applied after crops or weeds emerge from the soil.

Potash. The form of potassium listed in most fertilizer analyses.

Potassium (K). A primary plant nutrient, especially important for developing strong roots and stems. In fertilizers, usually expressed as potash.

Powdery mildew. Fine, white to gray, powdery fungal coating on leaves, stems, and flowers.

Predator. An animal that eats another animal.

Preemergent. A product applied before crops or weeds emerge from the soil.

Preharvest interval. The amount of time that must elapse (legally) after application of a pesticide before harvest takes place.

Preplant. A product applied before a crop is planted.

Prickle. A rigid, straight, or hooked outgrowth of bark or stems. Often called a thorn, but technically different. Roses are examples of plants with prickles. (See also Thorn.)

Primary nutrient. A nutrient required by plants in a relatively large amount (nitrogen, phosphorus, and potassium).

Primocane. First-year growth, usually vegetative, on caneberries. Only fall-bearing raspberries produce fruit on primocanes in late summer.

Processed fertilizer. A fertilizer that is manufactured or refined from natural ingredients to be more concentrated and more available to plants.

Propagate. To start new plants by seeding, budding, grafting, dividing, etc.

Prune. To remove plant parts to improve a plant's health, appearance, or productivity.

Pseudobulb. A thickened, aboveground, modified stem that serves as a storage organ. Found in some orchids.

Psocoptera. A major order of insects that have two pairs of wings, or are wingless, and chewing mouthparts (barklice, booklice).

Pubescent. Hairy.

Pupa. The stage between larva and adult in insects that go through complete metamorphosis.

Quarantine. A regulation forbidding sale or shipment of plants or plant parts, usually to prevent disease, insect, nematode, or weed invasion in an area.

Quick-release fertilizer. A fertilizer that contains nutrients in plant-available forms such as ammonium and nitrate. Fertilizer is readily soluble in water.

Raceme. A flower stalk on which the florets start blooming from the bottom of the stem and progress toward the top.

Radial spacing. The horizontal spacing of branches around a trunk.

Radicle. The root portion of an embryo.

Region of maturation. The area of the root where the enlarged root cells turn into the various root tissues.

Regulatory insect. Term used to describe insects that have an unknown impact in a new environment to which they may be moved.

Relative humidity. The ratio of water vapor in the air to the amount of water the air could hold at the current temperature and pressure.

Resistance. The ability of a host plant to prevent or reduce disease development by retarding multiplication of the pathogen within the host.

Respiration. The process by which carbohydrates are converted into energy. This energy builds new tissues, maintains the chemical processes, and allows growth within the plant.

Reversion growth. A stem that originates from and has the characteristics of the plant's rootstock. (See also Sucker.)

Rhizobia bacteria. Bacteria that live in association with roots of legumes and convert atmospheric nitrogen to plant-available forms, a process known as nitrogen fixation.

Rhizome. A stem that forms the main axis of the plant. Can form at or just below the ground (for example, in bearded iris).

Rhizosphere. The thin layer of soil immediately surrounding plant roots.

Root and stem rot. Soft and disintegrated roots and lower portions of the stem; sometimes results in death of the plant.

Root bound. A condition in which a plant's roots have completely filled its container. Typically, the roots begin to encircle the pot's outer edge. Further growth is prevented until the plant is removed from the container.

Root cap. The cells that protect the root tip as it pushes through the soil. These cells slough off and are replaced by others as roots grow downward.

Root cutting. An asexual method of propagation that involves removing a section of root from a 2- to 3-year-old plant during the dormant season and placing it into growing medium.

Root hair. Thin hair-like structure that grows from the epidermis of the region of maturation of the root. This structure absorbs water and nutrients from the soil.

Root knots. Swelling and deformation of roots.

Root meristem. A type of apical meristem located at the tips of roots. Provides for elongation of the roots and produces the cells that will become the epidermis, cortex, xylem, cambium, and phloem of the mature root.

Root pruning. The cutting or removal of some of a plant's roots.

Rootstock. The portion of a plant used to provide the root system and sometimes the lower part of the stem for a grafted plant.

Root sucker. See Sucker.

Rosette. A small cluster of leaves radially arranged in an overlapping pattern.

Rot. Decomposition and destruction of tissue.

Rotation. The practice of growing different plants in different locations each year to prevent the buildup of soilborne diseases and insect pests.

Row cover. A sheet of synthetic material used to cover plants in order to retain heat and exclude insect pests.

Rugose. Wrinkled.

Rogue. To uproot or destroy diseased or atypical plants.

Runner. See Stolon.

Russet. Yellowish-brown or reddish-brown scar tissue on the surface of a fruit. Also naturally occurring tissue on potato tubers.

Rust. Raised pustules on leaves, stems, and fruits; contain yellow-orange or rust-colored spore masses.

Sand. The coarsest type of soil particle.

Sanitation. The removal and disposal of infected plant parts; decontamination of tools, equipment, hands, etc.

Saprophyte. An organism that can subsist on nonliving matter.

Scab. Slightly raised, rough areas on fruits, tubers, leaves, or stems.

Scaffold branches. The principal branches of a tree or shrub arising from the trunk or another main branch to form the plant's framework.

Scale. (1) A modified leaf that protects a bud. (2) A type of insect pest.

Scarification. Artificial methods to soften the seed coat including scratching or rupturing the seed coat with sandpaper, nicking it with a knife, or degrading it with concentrated acid.

Scion. The portion of a plant or cultivar that is grafted onto a separate rootstock, consisting of a piece of shoot with dormant buds that will produce the stem and branches.

Secondary nutrient. A nutrient needed by plants in a moderate amount: calcium, magnesium, and sulfur. (See also Macronutrient, Primary nutrient.)

Secondary root. A type of root system that forms after the primary root emerges from a seed and branches outward.

Seed. Matured ovule that occurs as, or in, mature fruits.

Seed coat. The outer layer of a seed that provides protection for the enclosed embryo.

Seed coat impermeability. Caused by a hard seed coat that is impermeable to water, preventing the seed from germinating.

Seed dormancy. An adaptive feature of some plants to keep the seeds from germinating until conditions exist that favor seedling survival.

Seed leaf. See Cotyledon.

Seed scarification. Involves breaking, scratching, or softening the seed coat so that water can enter and begin the germination process.

Selective pesticide. A pesticide that kills only certain kinds of plants or animals; for example, 2,4-D kills broadleaf lawn weeds but leaves grass largely unharmed.

Self-fertile. A plant that produces seed with its own pollen.

Self-fruitful. A plant that bears fruit through self-pollination.

Self-pollination. Pollination that can occur when the anther and stigma are in the same flower or if the anther and stigma are in different flowers on the same plant or in different flowers on different plants of the same species, variety, or cultivar.

Self-sterile. A plant that needs pollen from another species, variety, or cultivar (e.g., cross-pollination).

Self-unfruitful. A plant that requires another variety for pollination. (See also Pollenizer.)

Senescence. The aging process. Also used to describe a plant that is in the process of going dormant for the season, although technically only the parts that are dying (the leaves) are becoming senescent.

Sepal. The outer covering of the flower when it is in the bud stage. They are leaflike in structure and usually green; however they can be colored and look like petals, as in tulips. They may fold back as in roses or remain upright as with carnations. Together, all the sepals form the calyx.

Separation. A term applied to a form of propagation by which plants that produce bulbs or corms multiply.

Sessile. Stalkless and attached directly at the base, as in sessile leaves.

Shear. To cut back a plant (as opposed to selective pruning or deadheading). Often used to regenerate plants with many small stems, where deadheading would be too time consuming.

Shoot. One season's branch growth. The bud scale scars (ring of small ridges) on a branch mark the start of a season's growth.

Shoot meristem. The apex of a shoot where cells actively divide to provide more cells that will expand and develop into the tissues and organs of the plant. Also called apical meristem.

Short-day plant. A plant requiring more than 12 hours of continuous darkness to stimulate a change in growth, e.g., a shift from the vegetative to reproductive phase. (See also Long-day plant, Day-neutral plant.)

Shot-hole. Roughly circular holes in leaves resulting from the dropping out of the central dead areas of spots.

Shoulder ring. One of the ridges around the base of a branch where it attaches to a trunk or to another branch. (See also Collar.)

Shrub. A woody plant that grows to a height of 3 to 12 feet. May have one or several stems with foliage extending nearly to the ground.

Side-dress. To apply fertilizer to the soil around a growing plant.

Sign. The part of a pathogen seen on a host plant.

Signal word. An indication of toxicity on pesticide labels. Pesticides labeled "caution" are the least toxic, those labeled "warning" are more so, and those labeled "danger" are the most toxic.

Silt. A type of soil particle that is intermediate in size between sand and clay.

Simple metamorphosis. A type of insect development involving three stages: egg, nymph, and adult. The nymph usually resembles the adult. (See also Complete metamorphosis.)

Siphonaptera. A major order of insects that have two pairs of wings, or are wingless, and piercing-sucking mouthparts as adults and chewing mouthparts as larvae (fleas).

Slow-release fertilizer. A fertilizer material that must be converted into a plant-available form by soil microorganisms.

Smut. Black masses of spores produced by fungi that may form on stems, ears, etc.

Soft pinch. To remove only the succulent tip of a shoot, usually with the fingertips.

Soil. A natural, biologically active mixture of weathered rock fragments and organic matter at the earth's surface.

Soilless mix. A potting medium consisting of ingredients such as sphagnum peat moss and vermiculite but no soil.

Soil salinity. A measure of the total soluble salts in a soil.

Soil solution. The solution of water and dissolved minerals found in soil pores.

Soil structure. The arrangement of soil particles or their aggregates.

Soil texture. How coarse or fine a soil is. Texture is determined by the proportions of sand, silt, and clay in the soil.

Solitary flower. A plant that forms a stalk that bears a single flower, such as a tulip.

Soluble salt. A mineral (salt) often remaining in soil from irrigation water, fertilizer, compost, or manure applications.

Sonic repeller. A sonic wave-emitting unit said to disrupt the activities of small mammals or insects but not proven to be effective.

Species. A group of individual plants interbreeding freely and having many (or all) characteristics in common.

Specific epithet. The second word in a Latin binomial. Sometimes called trivial name.

Specimen. An individual plant with outstanding characteristics (leaves, flowers, or bark), generally used as a focal point in a landscape.

Split complementary. In landscaping, use of a pure color and a color from either side of its complementary counterpart.

Spongy parenchyma. The lower layer of cells in the mesophyll.

Spore. (1) The reproductive body of a fungus or other lower plant, containing one or more cells. (2) A bacterial cell modified to survive in an adverse environment. (3) The reproductive unit of ferns.

Sport. See Mutation.

Spot treatment. To apply a pesticide to a small section or area of a crop.

Spur. Short, stubby stems common on fruit trees such as apples and pears. These spurs produce the flower buds.

Stamen. The male, pollen-producing part of a flower consisting of the anther and its supporting filament.

Staminate. Male flowers; flowers with no pistil (stamens only), also called imperfect because they lack the pistil.

Standard. A plant pruned so that it consists of a single bare vertical stem, atop which a shaped mass of foliage, usually globular, is maintained.

Stem cutting. A section of a stem prepared for vegetative propagation; forms adventitious roots on the stem.

Sterile. (1) Material that is free of disease organisms (pathogens), as in potting medium. (2) A plant that is unable to produce viable seeds.

Stigma. The receptive surface on a pistil that receives pollen.

Stipules. A pair of appendages found on many leaves where the petiole meets the stem.

Stock. See Rootstock.

Stolon. A horizontal stem, either fleshy or semiwoody, that runs along the soil surface.

Stomate, stomata (plural). An opening into a leaf that is formed by specialized epidermal cells on the underside (and sometimes upper sides) of the leaf.

Stone fruit. A fleshy fruit, such as a peach, plum, or cherry, usually having a single hard stone that encloses a seed. Also called a drupe.

Strain. A variation within a cultivar or variety.

Stratification. Chilling seed under moist conditions. This method mimics the conditions a seed might endure after it falls to the ground in the autumn and goes through a cold winter on the ground.

Style. On a pistil, a tube connecting the stigma and the ovary.

Stylet. A nematode's lancelike or needlelike mouthpart. Used to puncture and feed from plant cells.

Subapical meristem. Aids in formation of shoots and flowering stalks.

Subspecies. A major division of a species, more general in classification than a cultivar or variety.

Succession. The progression of a plant community to a stable mixture of plants.

Succession planting. (1) The practice of planting new crops in areas vacated by harvested crops. (2) Several smaller plantings made at timed intervals.

Sucker. A shoot or stem that originates underground from a plant's roots or trunk, or from a rootstock below the graft union. (See also Reversion growth.)

Summer annual. Annual plant in which the seed germinates in the spring, and the plant develops, matures, and produces seed by the end of the growing season.

Summer oil. A light refined horticultural oil used during the growing season to control insect pests and diseases.

Sunscald. Winter or summer injury to the trunk of a woody plant caused by hot sun and fluctuating temperatures. Typically, sunscalded bark splits and separates from the trunk.

Surfactant. See Additive.

Susceptibility. The condition of a plant in which it is prone to the damaging effects of a pathogen or other factor.

Sustainable gardening. Gardening practices that allow plants to thrive with minimal inputs of labor, water, fertilizer, and pesticides.

Symbiotic. Mutually beneficial.

Symptom. Visible reaction of a plant to disease such as wilting, necrosis, abnormal coloration, defoliation, fruit drop, abnormal cellular growth, or stunting.

Synthetic fertilizer. Chemically formulated fertilizers, mainly from inorganic sources.

Synthetic pesticide. Chemically formulated pesticide, mainly from inorganic sources.

Systemic. Spreading internally throughout the plant.

Systemic pesticide. A pesticide that moves throughout a target organism's system to cause its death.

Taproot. A type of root system that grows straight down with few lateral roots.

Taxonomy. Classification or naming of plants or animals.

Temporary branch. (1) A small shoot or branch left on a young tree's trunk for protection and nourishment. (2) A low lateral allowed to remain until a tree is tall enough to have scaffolds at the desired height.

Tender. Not tolerant of frost and cold temperatures. In horticulture, tender does not mean weak or susceptible to insect pests or diseases.

Tendril. A slender projection used for clinging, usually a modified leaf. Easily seen on vines such as grapes and clematis.

Terminal. The tip (apex), usually of a branch or shoot.

Terminal bud. The bud that is found at the tip of shoots.

Thatch. A brown, fibrous, spongy layer located between the soil and the grass blades.

Thermoperiod. The change in temperature from day to night.

Thermophilic. Growing at high temperatures, as in microorganisms that break down organic matter in a hot compost pile.

Thin. (1) To remove an entire shoot or limb where it originates. (2) To selectively remove plants or fruits to allow remaining plants or fruits to develop.

Thorn. A hard, sharp-pointed, leafless branch. Hawthorn is an example of a plant that produces thorns. (See also Prickle.)

Thysanoptera. A major order of insects that have two pairs of wings, or are wingless, and rasping-sucking mouthparts (thrips).

Thysanura. A major order of insects that are wingless and have chewing mouthparts (silverfish, firebrats).

Tiller. A shoot that arises from a plant's crown. Generally associated with grass species.

Tilth. The state of aggregation of a soil especially in relation to its suitability for crop growth.

Tissue culture. The process of generating new plants by placing small pieces of plant material onto a sterile medium.

Tolerant. A plant that will produce a normal yield even if infested by a disease or insect pest. (See also Immune, Resistant.)

Top-dressing. The practice of spreading a thin layer (1/4 inch) of soil, compost, humus, or a sand and peat mix over the turf or soil.

Topiary. A tree or shrub shaped and sheared into an ornamental, unnatural form, usually a geometric shape or the shape of an animal.

Totipotency. The ability of any cell to develop into an entire plant.

Trace element. See micronutrient.

Transpiration. The loss of water through the leaf stomata. The transpired water comes from the photosynthetic process and also from water in the cells.

Tree. A woody plant that typically grows more than 12 feet tall and has only one main stem or trunk.

Triadic. In landscaping, use of three colors that are at equal distances from each other on the color wheel.

Trichomes. The "hairs" that are extensions of the epidermal cells on a leaf.

Tropism. The tendency of a plant part to turn in response to an external stimulus, either by attraction or repulsion, as a leaf turns toward light. (See also Geotropism, Phototropism.)

Trunk. The main stem of a tree. Also called a bole.

Truss. A flower cluster, usually growing at the terminal of a stem or branch.

Tuber. A belowground stem used for food storage (e. g., potato).

Tuberous root. An underground storage organ made up of root tissue. Sprouts only from the point at which it was attached to the stem of the parent plant. Dahlias are an example.

Tuberous stem. A belowground stem consisting of a swollen hypocotyl, lower epicotyl, and upper primary root (for example, in tuberous begonias).

Turgor. Cellular water pressure; responsible for keeping cells firm.

Twig. A young stem (1-year-old or less) that is in the dormant winter stage (has no leaves).

Umbel. A group of flowers growing from a common point on a stem.

Understock. See Rootstock.

USDA zones. Areas derived by the USDA that indicate average-low winter temperatures. Used as a plant hardiness indicator. Other plant hardiness zones developed by other entities use different numbering systems.

Vaporization. The evaporation of the active ingredient in a pesticide during or after application.

Variety. In the wild, a plant growing within a species that is different in some particular characteristic from other members of that species. When grown from seed, a variety will maintain all of its particular characteristics. Also called a botanical variety.

Vascular pathogen. A disease-causing organism that invades primarily the conductive tissues (xylem or phloem) of the plant.

Vascular system. The internal structure of the stem that transports water, minerals, and sugars throughout the plant.

Vascular tissue. Water, nutrient, and photosynthate-conducting tissue. (See also Xylem, Phloem.)

Vector. A living organism that is able to transmit or spread a pathogen.

Vegetative bud. A type of bud that develops into shoots.

Vegetative propagation. The increase of plants by asexual means using vegetative parts. Normally results in a population of identical individuals. Can occur by either natural means (e.g., bulblets, cormels, offsets, plantlets, or runners) or artificial means (e.g., cuttings, division, budding, grafting, or layering).

Venation. The pattern of veins in leaves.

Vernation. The arrangement of new leaves within an older leaf sheath (e.g., on a grass plant).

Vertical spacing. The vertical space between branches on a tree.

Viable. Alive; seeds must be alive in order to germinate.

Viability. A seed's ability to germinate.

Virulent. Capable of causing severe disease.

Virus. An infectious agent composed of DNA or RNA, too small to see with a compound microscope. Multiplies only in living cells.

Water-holding capacity (WHC). The ability of a soil's micropores to hold water for plant use.

Water-soaking. Lesions that appear wet and dark and usually are sunken and or translucent. Often a symptom of bacterial disease.

Water sprout. A vigorous shoot originating above the ground on a plant's trunk, older wood, or bud union. Usually breaks from a latent bud. Often the result of heavy pruning.

Weed-and-feed. A combination fertilizer and herbicide sometimes used on lawns.

Whorled leaf arrangement. Three or more leaves are attached at the same point on the stem.

Wilt. Drooping and drying plant parts due to interference with the plant's ability to take up water and nutrients.

Wilting point. Point at which the water content within plant cells is low enough that cellular turgor is lost and the plant wilts.

Winter annual. Annual plant in which the seed germinates in the fall, producing a plant that overwinters, matures, and produces seed the following growing season.

Witches' broom. Abnormal brushlike development of many weak shoots.

Woody perennial. A plant that goes dormant in winter and begins growth in spring from aboveground stems.

Xeric. A plant or landscape that conserves water. Most xeric plants need minimal supplemental water after an establishment period (18 to 24 months after planting) unless there is extreme drought.

Xylem. The principal water conducting tissue of vascular plants.

Zone of elongation. The area of the root where the cells expand.

Compiled by Wayne Jones, Extension Educator, Bonneville County, and Anita Metzker, Master Gardener, Bonneville County.

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NSW DEPARTMENT OF PRIMARY INDUSTRIES

Going Organic

Organic Vegetable Production

A guide to convert to organic production

07/137



RIRDC Shaping the future

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NSW DEPARTMENT OF PRIMARY INDUSTRIES

Going Organic

Organic Vegetable Production

A guide to convert to organic production

by Robyn Neeson
NSW Department of Primary Industries, Yanco

RIRDC Publication Number 07/137

RIRDC Shaping the future



Foreword

Despite increased demand for organic products, particularly in export markets, farm conversion to organic agricultural systems in Australia is slow. An important impediment to conversion is lack of relevant information.

This document offers a comprehensive view of organic farming and the 'paddock-to-plate' requirements for successful organic vegetable production. It is one of three guides developed for organic agricultural systems—one each for vegetables, rice and soybeans, and rangeland livestock production. The guides arose as a result of a larger project that was coordinated by the NSW Department of Primary Industries and jointly sponsored by the Rural Industries Research and Development Corporation.

A series of workshops for NSW Department of Primary Industries staff and organic industry specialists underpinned the guides' development. During these workshops the similarities and differences between conventional and organic systems were discussed and, where possible, ways of overcoming any perceived impediments to conversion were identified. This formed the framework for the draft publications. Stage two of the project involved presentation of the drafts to organic and conventional producers at additional workshops across regional New South Wales and a final review by organic certifying organisations.

This publication does not aim to be prescriptive; rather, it provides a framework for organic conversion and pathways towards conversion. In addition to general organic principles, each guide describes possible methods of organic production for the commodity in question, the market potential, possible marketing strategies, the economics of production, processing requirements, and quality assurance.

True evaluation of the publication lies with practitioners. The authors hope the information provided will help make the transition to organic production a smooth one.

The project was funded from RIRDC core funds, which are provided by the Australian Government.

This report, an addition to RIRDC's diverse range of over 1700 research publications, forms part of the Organic Systems R&D Program, which aims to deliver R&D to facilitate the organic industry's capacity to meet rapidly increasing demand—domestically and globally.

Most of RIRDC's publications are available for viewing, downloading or purchasing online through the RIRDC website:

- downloads at www.rirdc.gov.au/fullreports/index.html
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Peter O'Brien
Managing Director
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Executive summary

Background

Market signals, both domestic and international, indicate significant demand for organically produced product. By the year 2015 it is predicted that the world trade in organic products will be US$100 billion. Australia has an opportunity to capture a proportion of this market. However, whilst demand for organic products is high, particularly in export markets, the rate of farm conversion to organic agricultural systems is relatively slow. Currently only about one percent of Australian producers are involved in organic production and the area devoted to such production is only about 0.8 percent of total area farmed.

What is the report about?

Fundamental to marketing an organic product is being able to prove to the consumer the organic integrity of the product 'from paddock to plate'. The publication offers readers a step-by-step guide through the organic conversion and certification process for a vegetable enterprise. Topics such as farm selection and establishment; weed, pest and disease management; soil and crop nutrition; variety selection; rotation design; and irrigation management are discussed. Case studies provide information about organic production of processing tomatoes, asparagus and pumpkins, and economic gross margins are given for rockmelons, sweet corn and pumpkins.

Organic vegetables are marketed through supermarkets, direct to restaurants, through organic retailers and wholesalers, via home delivery services, at farmers markets, and as exports. Marketing methods, promotional activities, and packaging and labelling requirements are described, as are the central features of developing effective marketing alliances.

Although organic farming essentially excludes the use of substances to provide crop nutrition and to treat weeds, pests and diseases, the organic standards do permit limited use of some substances. Soil health and crop pest, disease and weed management are discussed and a reference guide to the substances permitted under organic standards is provided. Of course, being organic does not relieve a farmer of the need to comply with state or territory and federal laws. Some of the regulatory requirements an organic vegetable producer might encounter are also discussed.

Finally, there is a comprehensive bibliography and a list of contacts for people keen to further explore the intricacies of organic agriculture and to help them with their farming and marketing activities.

Objectives

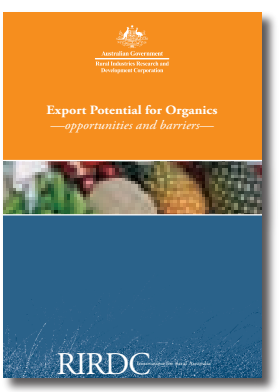
This publication does not aim to be prescriptive; rather, it provides a framework for organic conversion and pathways towards conversion within the field of organic vegetable production. It details general production principles for organic vegetables, as well as their production methods, market potential, possible marketing strategies, economics of production, processing requirements, and means of quality assurance.

Methods

A series of workshops for NSW Department of Primary Industries staff and organic industry specialists underpinned this publications development. During these workshops the similarities and differences between conventional and organic systems were discussed and, where possible, ways of overcoming any perceived impediments to conversion were identified. This formed the framework for the draft publications. Stage two of the project involved presentation of the drafts to organic and conventional producers at additional workshops across regional New South Wales and a final review by organic certifying organisations.

Results and Recommendations

The report draws together the information gathered from the workshops and other sources into a guide for producers of organic vegetables. It identifies the principles of organic farming and the requirements a producer needs to gain certification, including the relevant industry bodies and organisations. It discusses the range of on-farm and post-production aspects which influence the ability of a producer to meet standards for organic production and allow the delivery of the product to the most appropriate markets. The case studies provide examples of the organic production requirements for three different vegetable crops.



Export Potential for Organics—opportunities and barriers, *No. 06/061.*



1. Introduction to organic farming

This chapter provides an overview of the organic industry, the market potential for organic products, and the basic principles of organic production. Some of the production practices discussed here do not apply to rangeland producers, but the concept of creating and maintaining a holistic, dynamic farming system with emphasis on soil health and biological diversity does apply, no matter where the farm and what the products.

1.1 Industry size and structure

1.1.1 The world scene

Organic farming is practised in approximately 100 countries of the world. The total area of organically managed land worldwide is around 23 million hectares. Worldwide there are approximately 398 804 organic farms. (International Federation of Agriculture Movements 2003).

The retail value of the organic industry worldwide in 2005 was valued at US$30 billion. In 2005 organic retail sales accounted for US$13 billion in Europe, US$13 billion in the United States, and US$450 million in Japan. By the year 2015 it is predicted that the world trade in organic products will be US$100 billion. (International Federation of Agriculture Movements 2005).

The organic sector is reported to be growing at between 20 and 25 percent a year. If the growth rate experienced in Europe in the past 10 years continues, it is expected that, by 2010, 30 percent of food consumed will be organic. Some countries, such as the United Kingdom, have reported consistent growth in the consumption of organic foods (at 40 percent a year), with the increase in production (25 percent a year) failing to keep pace with demand.



Organic farming workshop

The New Zealand organic industry has enjoyed spectacular growth in recent years: exports increased from $1.1 million in 1990 to over $60 million in 2003. Europe, Japan and the United States are important markets for New Zealand organic produce: exports to Europe amounted to $28.7 million in 2003 and are expected to grow to over $100 million by 2008.

The International Federation of Agriculture Movements, a private organisation, is the peak world body for organic agriculture. It has about 700 member organisations from around the world and runs an international accreditation program. The Codex Alimentarius Commission (created in 1963 by the UN Food and Agriculture Organization and the World Health Organization) works to encourage all countries to harmonise standards and import controls for organic produce. Australia has played a central role in Codex's Organic Program, acting as chair for a number of years and regularly participating in negotiations to put forward the case for the Australian organic industry.

1.1.2 The Australian scene

It is estimated that there are about 2100 certified organic farming operations in Australia, farming about 10 million hectares. The number of organic farmers has increased by 10 to 15 percent in each of the past two years (Australian Certified Organic 2003). About 310 certified organic farms are located in New South Wales.

Estimates of the value of Australian organic produce vary. Australian Certified Organic's 2003 *Organic Food and Farming Report* estimated the farm-gate value for such produce in 2002 at A$90 million and exports (possibly reduced as a result of drought) at A$40 million. Australia-wide, in 2002 there were an estimated 500 certified processors and manufacturers of organic produce, contributing to an industry worth about A$300 million annually at retail level; this represents an increase of A$222 million since 1990. The Commonwealth Department of Agriculture, Fisheries and Forestry estimates that retail sales of organic produce in Australia increased from A$28 million in 1990 to nearly A$200 million in 2003 (press release, 21 August 2003). Wynen (2003) reports the retail value of

Australian organic produce to be A$165 million. RIRDC (2007) estimates the retail value for organic produce is worth between A$250 - A$400 million. The Organic Food and Farming Report suggests that growth is continuing at between 10 and 30 percent a year, depending on the sector. Beef, milk and horticulture were of particular note.

Almost 20 years ago pioneers of the organic industry asked the Australian Quarantine and Inspection Service for assistance in developing an export program and a national standard for organic production. In 1992 AQIS, in conjunction with the Organic Producers Advisory Committee (now the Organic Industry Export Consultative Committee), released the National Standard for Organic and Biodynamic Produce, which sets out the minimum requirements for organic products exported from Australia.

AQIS is responsible for accrediting organic industry organisations seeking to become an AQIS-approved certifying organisation. An audit of the organisation and its documented system is conducted against the requirements of the National Standard for Organic and Biodynamic Produce, the Export Control (Organic Produce Certification) Orders 1997, and importing country requirements. Once the organisation is approved, AQIS issues a Quality Management Certificate. At the time of writing seven organic certifying organisations were operating in Australia:

- Australian Certified Organic
- AUS-QUAL
- the Bio-Dynamic Research Institute
- NASAA—the National Association of Sustainable Agriculture Australia Ltd
- Organic Food Chain
- Tasmanian Organic Dynamic Producers
- Safe Food Production Queensland.

Appendix A provides contact details for these organisations.

The role of the certifying organisations is to ensure that products marketed under their logo are produced according to specific standards. Each organisation has its own standards in addition to the national standard. Figure 1.1 describes the certification framework for the Australian organic industry.

NASAA and Australian Certified Organic are the only Australian certifiers accredited by International Federation of Organic Agriculture Movements (IFOAM). They are also accredited with the United States Department of Agriculture National Organic Program (USDA NOP); also the Japanese Agriculture Standards (JAS) administered by the Japan Ministry of Agriculture Forestry and Fisheries (MAFF), this recognition provides market access to these countries for Australian certified products, which have been accredited by these respective systems. Sections 3.3 and 6.1 provide more information about obtaining organic certification and the organic Export Control Program.

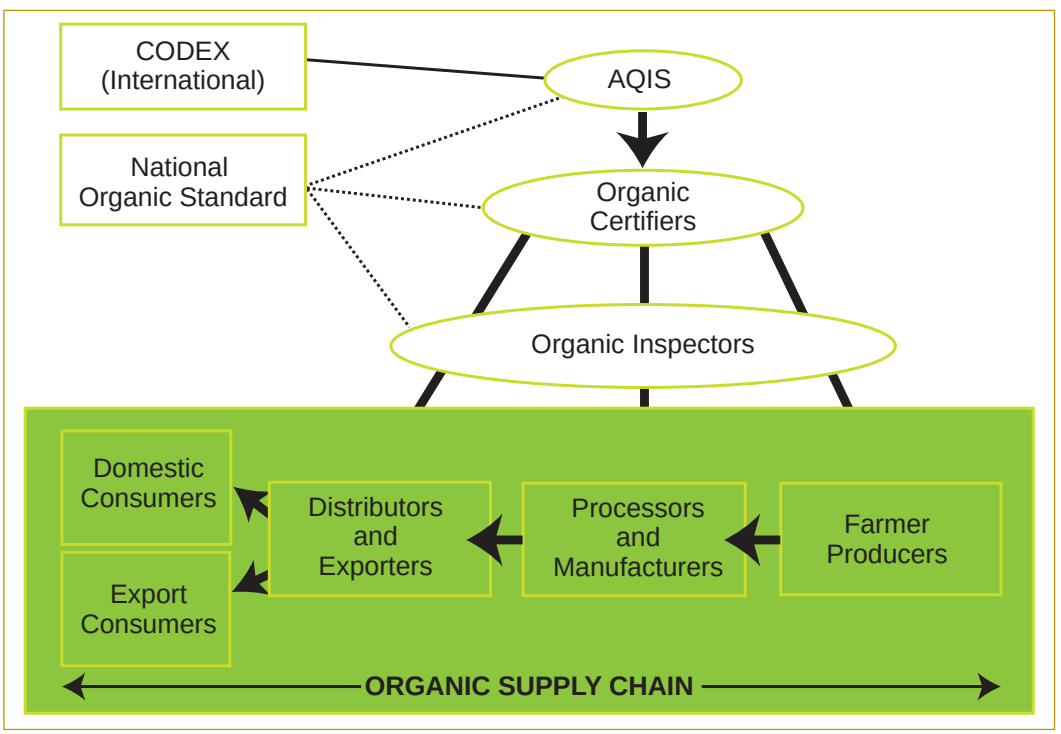


Figure 1.1 Certification framework for the Australian organic industry.

Source: May and Monk (2001)

1.2 Market potential for organic vegetables

Horticultural produce leads the domestic market in terms of growth in organic products. In 1995 the Rural Industries Research and Development Corporation valued Australian organic vegetable and herb retail sales at $28.06 million. Wynen (2003) put the retail value of horticultural products at abut A$48 million in 2000–01, with vegetables accounting for 13 percent of national organic production (see Table 1.1).

Target markets see Australia as having great potential to supply both fresh and processed vegetable products, largely to meet out-of-season needs. At present an undersupply of organic produce is limiting Australia's ability to meet export demand, and temporary shortfalls have occurred in the domestic market as product is redirected to export markets. McCoy and Parlevliet (2000), from Agriculture WA, identified a range of organic products as having a high priority for further development (see Table 1.2).

Compared with the United States, Europe and Japan, in Australia the domestic market for organic vegetables is expanding slowly. Relatively few wholesalers, located in the larger cities, receive the majority of fresh vegetables, distributing to specialty and health food stores, home delivery services and, increasingly, the big supermarket chains Coles Myer and Woolworths. Producers supplying these outlets report mixed experiences. Oversupply seems to occur relatively easily for most lines during peak production times, suggesting that the market is in the main a small one.

Producers that can supply seasonal niches (early or late season), 'novelty' vegetables (such as mini-vegetables) or difficult-to-grow vegetables have little difficulty selling their products, usually for a significant premium. Wholesalers report mixed quality but say that product quality and presentation are generally improving. Excessive price premiums—averaging 30 percent but sometimes much greater—could be restricting sales and hampering the industry's expansion.

Farmers' markets are becoming an increasingly popular way for producers to sell their produce. Large farmers' markets operate in the major capital cities on most weekends. Regional markets are also growing: some regional centres are using them as a way of promoting local produce and increasing tourism. Fresh and value-added produce such as chutneys and jams are the most commonly sold items.

Domestic processors are producing a range of organic vegetable products, among them canned asparagus and sweet corn, pasta sauces, potato crisps and baby food. Heinz Watties is producing frozen vegetable and baby food lines but is currently obtaining the ingredients from organic producers in New Zealand.

Table 1.1 National values of horticultural organic produce: farm-gate and retail prices, 2000–01

	Farm-gate price		Retail price
Product	$'000	% of national organic production	$'000
Vegetables	11 509	13	25 148
Fruit	4 070	5	8 889
General	2 249	3	4 915
Citrus	3 416	4	7 464
Grapes	348	0	659
Dried fruit	544	1	999
Nuts			
Total	22 136	25	48 075

Source: Adapted from Wynen (2003).

Table 1.2 Organic products for further development

Priority	Likely	Possible
Beef	Apples	Broccoli
Carrots	Asparagus	Eggs
Citrus	Bananas	Fish
Wheat	Canola	Grapes
Wine	Dairy products	Herbs
	Honey	Nectarines
	Oats	Pears
	Rice	Plums
	Soybeans	Poultry
	Safflower	Potatoes
	Sugar	Sunflower
	Onions	

Source: McCoy and Parlevliet (2000).

In 2003 Smith reported that Australian exported about 16 000 tonnes of organic product in 2002, about three-quarters of this being grain. The main destinations for the exports were the United Kingdom and Europe, and fruit and fruit products accounted for about 8 percent. Between 2000 and 2002 the main areas of growth were in exports of certified organic meats and in oils and fats; exports of certified organic vegetables fell sharply (Smith 2003).

Of the top 10 export destinations for Australian organic produce in 2001, six were in Europe—the United Kingdom, Italy, Switzerland, France, the Netherlands and Germany—and accounted for over 70 percent of all Australian organic exports. Other important markets in 2001 were Japan (12 percent), Singapore (5.5 percent), the United States (5 percent) and New Zealand (2 percent) (Smith 2003).

At present about 40 percent of Australian organic production is destined for the export market. There is a distinct and growing market for fresh and frozen organic vegetables in the United Kingdom, France, Germany and Japan. Among the factors promoting this demand are food safety, genetically modified organisms, and environmental concerns.

Estimates suggest that in the United Kingdom 70% of organic fruit and vegetables and 50 percent of organic cereal products are imported. In 1996 the market for organic vegetables in Europe was worth US$200 million a year, and it was predicted that this would reach US$510 million by 2003. Other destinations offering export potential are Japan, the United States, Singapore, Korea and Malaysia.

Holmes and Kreidl (2003) reported that market opportunities for Australian organic products would open up if phytosanitary restrictions to importing countries were relaxed. They referred specifically to opportunities for organic fruit and vegetables in Japan (lemons, limes, grapes, olives, cucumbers, marrow, pumpkin, squash, zucchini, beans and eggplant), South Korea (lemons and limes), Taiwan (lemons, limes, grapes, olives, cucumbers, rockmelons, honeydew melons, watermelons, pumpkin, squash, zucchini, beans and eggplant), the United States (lemons, limes, grapes, cucumbers, pumpkin, squash, zucchini, eggplant and blueberries), and the European Union (navel oranges, apples, pears and table grapes). They noted that development of alternative disinfestation methods for asparagus was a high priority.

Import replacement is another market sector that warrants consideration. A large range of imported organic products are currently sold in supermarkets and health food outlets. Shepherd, Gunner, and Brown. (2003) reported that pureed vegetables for baby food offer import replacement opportunities in the Australian domestic market.

The estimated value of organic products imported into Australia in 2003 was A$13 million (*Organic Monitor* 2004, in DAFF 2004). In relation to imports, Department of Agriculture, Fisheries and Forestry reported:

> Over half of imported organic products are processed foods, such as biscuits, breakfast cereals, muesli, chocolate, pasta, soups, coffee, tea and other beverages. Most global organic food processing occurs in North America and the European Union and it is these two regions that supply the majority of organic processed food imported into Australia.
>
> Other organic imports include herbs, spices, grains, pulses, nuts, dried fruits, rice, honey, sunflower oil and olive oil. Organic fruit and vegetables are mainly imported from New Zealand to meet shortfalls in domestic supply. Apart from organic food and drinks, an increasing number of organic personal care products such as skin care products, hair care products, deodorants and soaps are imported into Australia.
>
> …
>
> It is not clear whether imports are replacing shortfalls in Australian production or competing with domestic products. Certainly some products similar to those imported are produced in Australia and even exported. (DAFF 2004, pp. 32–3)

On this basis, it seems likely that there is the potential for an increase in the domestic production of certain organic products to replace similar imported products.

The current situation for organic products in Australia is perhaps best summarised by Hallam:

> The market for organic food is still small and therefore susceptible to oversupply, at least at particular times and locations. While many countries report strong growth in demand for organic meat and dairy products, for example, a number of instances can be cited where supply has exceeded demand. This has resulted in either a severe reduction in the price difference between organic and conventional products or organic products being sold as conventional products. (2003, p. 17)

2. Organic production principles: an overview

Organic agriculture is defined worldwide as 'farming without the addition of artificial chemicals'. An artificial chemical is one that has been manufactured or processed chemically. For example, rock phosphate is acceptable on an organic farm but superphosphate is not. The difference is that superphosphate is rock phosphate with a manufactured chemical (sulphuric acid) added to make more of the phosphate soluble. The definition includes the word 'addition' because organic farming is not necessarily chemical-free farming. The reason for this is that we live in a world where there are artificial chemicals in the soil, the water and the air.

Like many other words, 'organic' has several meanings. In the context of agriculture it refers to whole-farm management—the farm being treated as a living organism. Traditionally, organic farms aim for optimal production rather than yield maximisation. They seek to operate as closed systems, using renewable resources wherever possible and with, as far as practicable, reduced reliance on outside (off-farm) inputs. Organic farms can be managerially more complex, but they are less dependent on external inputs.

Organic systems are essentially biological systems—both above and below the soil. Pest, disease and weed control must, in the first instance, encourage and maintain natural biological processes so as to balance disease and pest problems. Management strategies based on an understanding of biological cycles and other interactions are the main tools replacing reliance on synthetic inputs such as artificial herbicides, insecticides, fungicides, animal drenches, superphosphate and urea.



Management strategies based on an understanding of biological cycles and other interactions are the main tools for replacing reliance on synthetic inputs such as artificial herbicides, insecticides, fungicides, drenches, superphosphate and urea.

Biodynamic agriculture is a type of organic farming. It developed from a series of eight lectures on agriculture given in 1924 by Austrian Rudolf Steiner (1861–1925), founder of the spiritual system known as anthroposophy. The lectures were a response to farmers' observations that soils were becoming depleted and there was a deterioration in the health and quality of crops and livestock following the introduction of chemical fertilisers at the turn of the century. Steiner believed a renewal in agriculture was necessary in order to find a way to re-invigorate the earth.

Biodynamic agriculture sees the farm as a living organism interacting with its environment to build healthy soil and nutritious food that sustains plants, animals and hence humankind. Emphasis is placed on the integration of crops and livestock, the recycling of nutrients, and the health and wellbeing of crops and animals. The farmer, too, is part of the whole. These interactions within the farm ecosystem lead to a range of management practices that take account of the environmental, social and financial aspects of the farm as a whole.

Although biodynamics parallels organic farming in many ways—especially in connection with cultural and biological farming practices—it stands apart from other organic agriculture systems by virtue of its association with the spiritual science of anthroposophy. Steiner identified energies working in nature and so proposed practices that would deploy those energies. He emphasised farming practices designed to achieve balance between the physical and higher, non-physical realms, that acknowledge the influence of cosmic and terrestrial forces, and that aim to imbue the farm, its products and its inhabitants with life energy.[1]

Biodynamic farmers aim to develop a soil rich in humus; this is facilitated by practices involving careful use of plants, animals,

1. The higher, non-physical, realms are the etheric, the astral and the ego. The terminology and the complex underlying concepts of anthroposophy can make biodynamics hard to grasp. Biodynamic farmers believe there are forces beyond gravity, chemistry and physics that influence biological systems.

machinery and special preparations. Humus—decomposed organic matter made up principally of water—assists in binding soil particles and holding on to soil nutrients. It binds with clay particles to form a clay–humus complex. Among biodynamic humus-building practices are the following:

- use of special preparations to stimulate biological activity
- application of composts containing special preparations
- use of cover crops and green manure
- crop rotations and companion planting
- appropriate tillage
- addition of rock dusts, lime and rock phosphate as required.

A distinguishing feature of biodynamic farming is the use of nine preparations designed to improve soil quality and stimulate plant life. The preparations consist of mineral, plant or animal manure extracts, usually fermented and applied in small proportions to compost, manures, the soil or plants after dilution and specialised stirring. The intention is to moderate and regulate biological processes as well as strengthen the life (etheric) forces on the farm. The preparations are used in homeopathic quantities—that is, in extremely diluted amounts. They are numbered BD 500 to BD 508.

2.1 Soil management and crop nutrition

There is worldwide agreement in organic standards that organic farming systems should maintain or increase soil fertility on a long-term basis. Australia's organic standard, the *National Standard for Organic and BioDynamic Produce* states that the primary aims of organic agriculture are as follows:

- producing food of high nutritional value
- improving biological cycles in farming systems
- maintaining and increasing soil fertility
- working as far as practicable within a closed system
- avoiding pollution resulting from agriculture
- minimising the use of non-renewable resources
- co-existing with and protecting the environment (OIECC 2002).

This is achieved through:

> 'management practices that create soils of enhanced biological activity … such that plants are fed through the soil ecosystem and not primarily through soluble fertilisers added to the soil … Organic farming systems rely to the maximum extent feasible upon crop rotations, crop residues, animal manures, legumes, green manures, mechanical cultivation, approved mineral-bearing rocks … to maintain soil productivity and tilth and to supply plant nutrients …' (AQIS 2002)

Initially, conversion from a conventional fertiliser regime to an organic soil-building process involves eliminating the use of artificial chemicals in the farming system. Fertilisers such as superphosphate and ammonium nitrate are thus excluded and are replaced by practices that foster the cyclic renewal of nutrients to maintain crop health. Organic matter content, microbial activity and general soil health are taken as measures of soil fertility. An analysis of organic farming systems in Europe (Stolze et al. 2000) found that organic farming increased microbial activity by 30 to 100 per cent and microbial biomass by 20 to 30 per cent.

A comparative study of organic, conventional and integrated apple production systems in Washington State from 1994 to 1999 found that the organic and integrated systems had higher soil quality and potentially lower negative environmental impacts than the conventional system. The data showed that the organic system ranked first in environmental and economic sustainability, the integrated system second and the conventional system last (Reganold et al. 2001).

Research into the sustainability of organic farming systems in Australia has been limited. The work that has been done has



Testing the soil



Organic farming starts with the soil. Photo source: Should I Convert to Organic Farming by Viv Burnett, Robyn Neeson and Els Wynen. RIRDC Publication No. 05/084

tended to focus on comparative studies in broad-acre, or extensive, cropping and livestock systems, which are characterised by their low use of external inputs. Rock phosphate, lime, dolomite, legume rotations, incorporation of green manures and crop refuse, manure application during livestock grazing, and the application of microbial preparations can be used for building soil fertility.

Studies by Penfold (1995), Derrick (1996), Deria et al. (1996) and Schwarz (1999) suggest a trend towards deficiencies in phosphorous, nitrogen and sometimes sulphur under current organic management regimes in broad-acre cropping and livestock systems.

The limited studies of intensive organic farming systems in Australia have generally shown an increase in soil health compared with conventional practice (Wells & Chan 1996; Huxley & Littlejohn 1997; Stevenson & Tabart 1998). This could largely be a reflection of the cost-effectiveness of larger applications of commercial organic fertilisers and compost and incorporation of green manures for high-value crops such as fruit, vegetables and herbs.

2.2 Livestock management

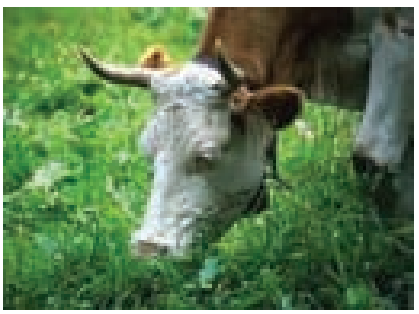
Livestock play an important part in organic farming systems, including those producing vegetables. In fact, some certifiers might demand that livestock (such as poultry) or livestock by-products (such as composted manures) be used as part of the organic vegetable rotation.

Nitrogen fixed by legumes and other nutrients consumed by livestock during grazing are returned to soil in manure and urine. Managed carefully, livestock and manure can play an important role in nutrient cycling on an organic farm. Composting of livestock manure is generally required, particularly if sourced externally to the organic farm.

Livestock are used extensively for weed control on organic farms. For example, they can graze down weeds before a crop is sown or they can be used after crop establishment for weed control and to improve tillering. Crops can sometimes be chosen so that livestock selectively graze out weeds, leaving behind the less palatable crop. Chinese weeder geese are often used in organic vegetable and fruit production to selectively remove grasses and some broad-leaf weeds from crops.

Livestock can also help with preparing the ground for planting by grazing and trampling crop stubble and reducing the length of a pasture sward.

The pasture phase in a mixed cropping–livestock system builds critical fertility and structure into rotations and reduces potential for the build-up of insects and disease.



Organic principles encourage the natural behaviour of livestock

2.2.1 Livestock nutrition

In organic farming, animal husbandry aims to provide a diet that livestock are best adapted to; the aim is not to maximise weight gain at the expense of animal health and contentment. Although good nutrition seeks to produce adequate yields, it has an enormous effect on animal health and is therefore very important in disease prevention.

Dietary diversity is the key. A balanced diet helps to meet the animals' physiological needs. Lampkin (1990) points out that cows with high production levels as a result of emphasis on concentrates in their diet have a shorter productive life. In organic systems crop rotation and a variety of plant species in the pasture help to achieve diet diversity. A mixture of deep-rooted and shallow-rooted species increases the potential for nutrients to be available and helps eliminate nutrient deficiencies. Herbs such as chicory, plantain, yarrow and caraway are often added. Deep-rooted native species can recycle and make available nutrients that otherwise remain unavailable, deep in the soil. Legumes such as lucerne can supply organic nitrogen to the grass component of pastures and help recycle deep nutrients.

Nutrient imbalances are less likely to occur in organically raised livestock when plant nutrients are provided through the balancing of soil fertility and the soil's biological activity, rather than when water-soluble nutrients are provided.

The long-term aim of organic systems is to remedy soil deficiencies. Under the organic standards, any mineral supplements used should be from natural sources. For example, additives such as urea and synthetic amino acids are not permitted, whereas seaweed and seaweed extracts, which contain a range of minerals, are. Nutrients can



Organic beef. Photo: Andy Monk

also be provided in mineral licks and fodder mixes or by drenching. Exceptions are made for potassium-based fertilisers.

The National Standard for Organic and Biodynamic Produce requires that all food for organic livestock be produced organically—either as purchased input or, preferably, produced on the farm. Special conditions exist in relation to feeding supplements and rations and feeding during drought. The national standard and certifiers' standards should be consulted in this regard.

2.2.2 Soil management for nutritious pastures

Slow, organic remediation of soils through improved biological activity provides balanced plant nutrition and growth and hence improved nutrition for livestock. The aim is to build soil fertility through practices such as incorporating green manure and cultivating in such a way as to improve soil aeration.

2.2.3 Breeding

In conventional livestock systems the genetic emphasis is on high production. The organic farmer selects livestock for a wider range of qualities, among them pest (parasite) and disease tolerance or resistance (for example, Brahman tick tolerance) and mothering ability. Breeding for lifetime yield is more commonly the practice in organic farming. While the aim of conventional livestock production is for high, early productivity, the aim with organic livestock is to increase the animals' productive life, and this is often associated with resistance to disease (Boehncke 1990). Developing longevity in the herd offers a number of advantages:

- A long growth period means a long youth, and a long immature stage has been shown to be a precondition for a longer life.
- The farmer has the opportunity to get to know the herd, which makes handling easier and allows for a thorough knowledge of the herd's disease history.
- The herd establishes a stable social order and a stable health state.
- Stress factors become adapted to conditions over a longer period.
- The quality and quantity of colostrum in older cows is greater.

Breeding should be within the genetic capacity of the species concerned. For example, breeding for high feed conversion can lead to arthritis and breeding for large hindquarters can lead to birthing difficulties.

During conversion to organic production, livestock bought externally must be organic or, if conventional, placed in a quarantine area for three weeks. Once the farm is fully organic, external purchases are confined to breeding stock only: all other livestock should be bred on the property. Replacement breeders may be introduced at an annual rate of 10–20 per cent (depending on the certification organisation) of the existing breeding stock. A limited provision does, however, exist in the standards for taking on agisted stock.

Livestock produced by artificial insemination are allowed by most certification organisations if natural behaviour is not practical or new genetic material is required. Embryo transplant is not permitted since this technique usually necessitates hormone injection to synchronise breeding cycles and tends to lead to decreased diversity in the herd. Livestock produced using genetic engineering are not permitted.

2.2.4 Livestock welfare

Organic farmers aim to minimise physical and psychological stress in their livestock in order to promote wellbeing and reduce the incidence of disease. Having non-stressed livestock also helps reduce veterinary bills and maintain meat tenderness.

The national standard states, 'Livestock husbandry practices that reflect the behavioural needs and ethical treatment and welfare management of livestock are also of fundamental importance where animals are kept on the farm' and, in relation to stress caused by practices such as castrating, marking and mulesing, 'Pain inflicted by surgical treatments must be kept to a minimum level and duration'. For example, NASAA prohibits practices such as de-tailing of cows, although de-horning and castration are allowed when carried out as humanely as possible and within specific age limits. Use of anaesthetics is permitted: it does

not result in loss of organic or biodynamic status.

Management aims to minimise stress during potentially stressful periods. After shearing, for example, stress can be reduced by providing good pasture with low or no parasitic infection. Reducing noise and not rushing stock through gateways can also help minimise stress during handling.

Animals experience added stress when being transported to market and during slaughter. The NASAA standards state, 'Slaughter will be carried out quickly and without undue stress … animals may not be held or herded in an area where the killing of other livestock is visible'.

The benefits of shade and shelter for livestock are well documented. Organic animal husbandry requires that sufficient protection be provided against excessive sunlight, temperature, wind, rain and other harsh climatic conditions. This can be achieved through the provision of windbreaks and sheltered paddocks. Livestock such as geese should be protected from predators such as foxes and dogs.

2.2.5 Livestock health

The organic approach to animal health care focuses on prevention of disease through diet, shelter, breeding and husbandry practices, rather than treatment. It is not possible to eliminate all animal disease, but when disease does occur a healthy animal is in a better position to cope with it. For many organic farmers, good observation is an important part of disease management. A producer who keeps daily or frequent records will be in a better position to identify the possible origins of a disease or injury.

Organic standards exclude the routine use of veterinary drugs such as antibiotics and some vaccinations. Organic farmers rely instead on treatments such as herbs, vitamins and minerals, homoeopathy, acupuncture, and dietary additives such as pro-biotics. There is, however, not always a satisfactory 'organic treatment' for health problems, and when an organic treatment is not effective there is no doubt that conventional treatment must be used: the welfare of the animal is paramount.

Where an animal is treated with a non-permitted substance it:

> must be identified and quarantined from other stock from the time of treatment for at least three times the withholding period or three weeks, whichever is the greater, specified for the treatment under relevant laws … For a period of at least 12 months after quarantine, such areas shall only be used for livestock production. Crops labelled as organic or bio-dynamic intended for human consumption can be grown on the area after this period. (AQIS 2002)

Therapeutic treatment with allopathic veterinary drugs or antibiotics is permitted. Following such treatment, however, livestock may not be sold as organic or biodynamic. Their products and/or progeny may be sold as organic or biodynamic after a minimum management period, as outlined in the standard. Where a law requires the treatment of diseases or pests, this overrules the organic standards.

Selection of stock on the basis of disease tolerance and resistance is an important tool of the organic farmer. Recurrent health problems point to something amiss in the system. If individual stock exhibit recurrent problems they should be culled.

Internal parasites

Organic farmers are not permitted to use conventional anti-worm preparations. Drenching is done only when necessary, as routine use is not permitted and could lead to the development of resistance. If permitted substances or practices do not satisfactorily treat an animal, the animal's welfare takes priority over organic status.

Among the organic treatments used are drenches made from a mixture of natural products such as garlic, molasses, vegetable oil and cider vinegar. Copper sulphate in minute doses is also favoured by some organic farmers. Others use aloe vera, clay products, diatomaceous earth, other vegetable and tree products, and Nutrimol®. Homoeopathic remedies are widely



Grazing management is an important tool in managing parasites.

used, with reported excellent results.

Some substances listed as permissible are not registered as veterinary treatments, and the Organic Industry Export Consultative Committee, which is responsible for approving changes to the National Standard for Organic and Biodynamic Produce, has been asked to explore the legality of using these unregistered substances.

Alternative management practices aim to disrupt a parasite's life cycle. Temperature and moisture favour the development of internal parasites, so after rainfall or irrigation livestock are moved to a clean pasture; alternatively, pastures can be harrowed following grazing to expose the eggs and larvae to sunlight and heat. The New Zealand Agroecology Program found pastures such as chicory and lucerne to be least conducive to parasite larvae intake.

Resistance to internal parasites increases with age because immunity develops through previous exposure. Sheep reach a higher level of resistance at about nine months, whereas cattle reach this stage at about 18 months. Late pregnancy, lambing and weaning are critical periods for infection because resistance drops with increased stress and as feed intake increases, so it is critical to provide clean pasture at these times. Good nutrition and grazing rotations assist in developing and maintaining resistance.

Grazing management is very important in managing parasites. Spelling paddocks can control worm populations, as can alternate grazing. This latter method can involve older, less susceptible stock grazing wormier pastures before young stock or having a higher number of less susceptible stock together with young stock. Another form of alternate grazing is to graze alternately with different species—for example, cattle before sheep because cross-infection does not occur to any great extent—or with different species together. This also offers benefits in terms of weeds: different grazing habits will prevent the domination of a particular weed species. Strip grazing involves back-fencing stock to match larvae development so that the stock do not contaminate their pasture. Most organic farmers prefer low stocking rates and relatively intensive rotations.

Cultivation and intermediate cropping allow for a break in the build-up of insects, parasites and disease and therefore a clean pasture. Sowing mustard and ploughing it in as a green manure has been shown to clean a pasture (Belstead & Belstead 1992).

In summary, maintaining good health and reducing the risk of parasites involves the following:

- maintaining a high plane of nutrition and minimum stress
- grazing management that reduces exposure to parasites
- eliminating herd drenching and drenching individual stock only when infection is sighted—close observation is crucial here
- after the system is established, culling of animals that show signs of heavy infestation.

2.3 Plant pest and disease management

Organic systems are designed to re-create natural systems, which support several competing species, so that no single species has a consistent advantage. This is contrary to the main objective of modern agricultural systems, where the enterprise must maintain permanent control in order to be viable. Organic producers also believe that, by maintaining a vigorous and healthy crop through the adoption of sound cultural practices, plants are better able to withstand attack from pests and disease. Predicting potential problems and developing strategies to prevent the problems from occurring is the key to successful organic pest and disease management. Organic farmers take an 'integrated pest and disease management' approach. Such an approach is sometimes called 'ecological pest management' in the case of organic farming, to differentiate it from integrated pest and disease management in conventional farming, which includes the use of pesticides. Pesticides are generally not available to organic farmers, although some substances that are derived naturally are allowed for restricted use—for example, natural pyrethrum and *Bacillus thuringiensis*).

In organic systems integrated pest and disease management makes use of a range of non-chemical techniques:

- cultural controls such as crop rotation, cultivation and crop manipulation—for example, varying the crop spacing and the planting time—and crop hygiene
- manipulation of species diversity—for example, increasing the number of plant



Biological pest control is encouraged in organic systems. Predatory shield bug parasitises Heliothis caterpillar in a pigeon pea trap crop. Photo: R Neeson

species that act as a barrier to a pest or that provide an alternative (preferred) host

- crop resistance or other physical attributes of the crop—such as spines or hairs—that deter pests
- natural and biological controls—for example, encouraging the natural enemies (parasites, predators and disease organisms) of a pest species by providing a favourable habitat or food source
- mechanical controls to trap or kill pests or physically prevent them from gaining access to crops
- modification of the physical environment—for example, using light traps and sticky traps (to trap and monitor insect pests), laying down clear plastic to control weeds (solarisation), planting a crop such as canola that inhibits certain pest species (known as bio-fumigation), or planting antagonistic species (known as allelopathy) for weed control

use of livestock—for example, using ducks and geese to reduce populations of snails and maintain hygiene by consuming crop refuse.

2.4 Weed management

Economic weed control—without the assistance of synthetic herbicides—remains one of the most difficult aspects of successful organic production.

A well-managed organic system should not develop a significant weed problem. A primary objective for organic farming is to change the composition of the weed community, so that the farming system gains maximum benefit. Sometimes, however, one weed species might dominate or a noxious weed (one that, by law, must be controlled) might be present and this situation must be managed.

Whereas most conventional farmers see a weed as something that grows where it is not wanted, organic farmers see it as a sign that something in the farming system needs attention. Weeds are also seen as having an important ecological role: for example, some deep-rooted species will recycle nutrients from deep down in the soil profile, making them available to shallow-rooted species.

In order to develop an integrated strategy for suppressing weeds without using chemicals, organic farmers need to have a good understanding of weeds' behaviour, their growth characteristics, and the conditions that favour their



Organic farmers use a range of innovative techniques to manage weeds. Pictured is a tractor-mounted hot-air weed steamer. Photo: R Neeson.

3. Gaining organic certification

Conversion to organic farming is a dynamic process: it involves conceptualising, then action and observation, and finally reflection and refinement. It is a cyclical and continuous process. Figure 3.1 illustrates the concept.

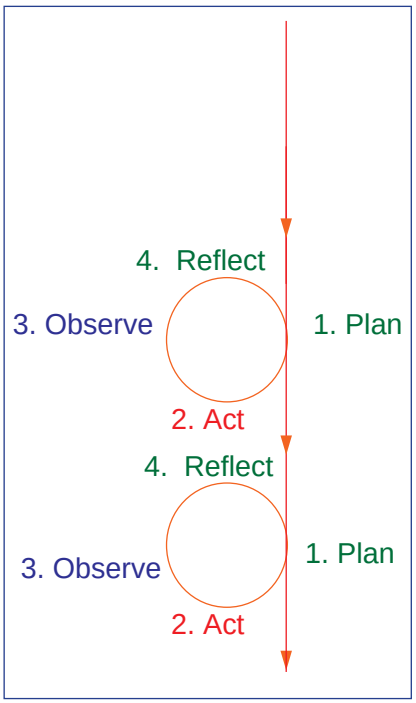


Figure 3.1 An action learning model. Source: Kolb (1984)

Observation and reflection are particularly important because organic systems are, by their nature, holistic. A change to one component of the system will affect other components. Monitoring and recording the consequences of implementing a change are crucial to success.

Planning is an essential requirement of any business—not least an organic enterprise. To put it simply, if there is no planning the venture will almost undoubtedly fail.

3.1 A self-assessment test

Organic conversion starts with personal conversion—for you and your thinking. You must be committed to strictly following organic principles, yet be flexible enough to work with the ever-changing face of nature. Information is not readily available through conventional sources, so be prepared to spend many hours researching and testing new techniques. The self-assessment test shown in Figure 3.2 is designed to help aspiring organic farmers decide how far along the conversion pathway they are.

3.2 Beginning the conversion

John Melville, from Bioterm Consulting Pty Ltd, has a message for aspiring organic farmers: 'A problem is a positive opportunity for development'. This is how the farm conversion process should be considered; failures should not be seen as problems but rather as a way of moving forward and developing and improving your organic system step by step.

Conversion begins by making small changes that will have the biggest impact on the farming system. It is best to change small aspects of management that can be implemented without excessive cost or loss of crop yield or quality. Avoid trying to change to total organic management immediately.

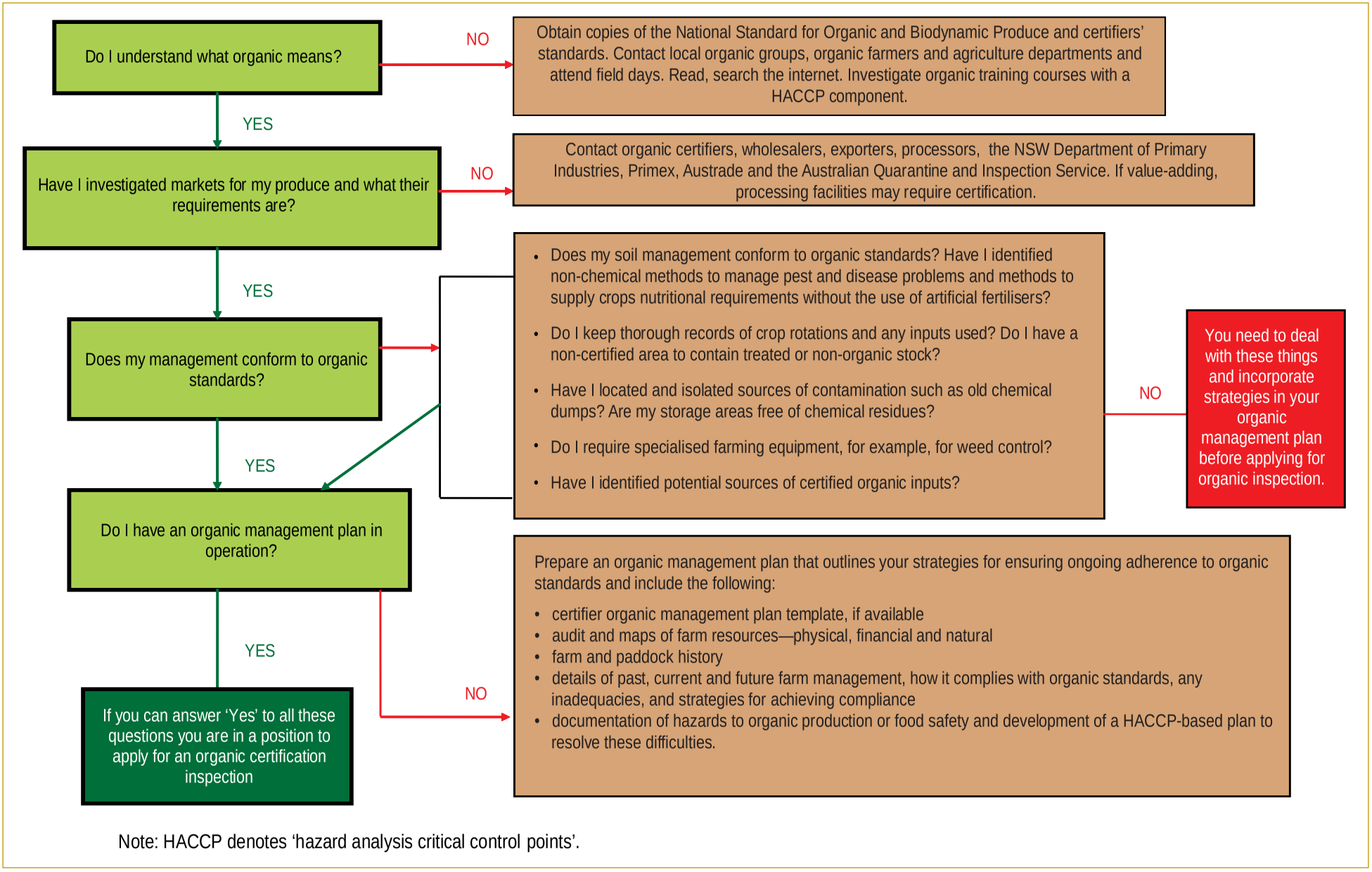
Changes to soil fertility and soil management should be considered early in the process. This will involve conducting soil analyses, determining how to substitute non-organic fertiliser inputs with organic inputs and crop rotation practices (for example, green manuring) and assessing current cultivation practices. Locating organic inputs can be time-consuming and costly; some certification organisations do, however, provide a database of suppliers of certified organic inputs. Livestock can play an important role in the future soil fertility program, so it is also necessary to investigate how stock can be managed organically.

Paying increased attention to pest monitoring and determining ways of reducing pesticide applications form another area that should receive high priority during the early stages of conversion. It is worth considering employing a crop-check consultant to help with pest and predator identification and the development of strategies to predict and manage pest incursions.

Noxious weeds and other difficult-to-control weeds (such as perennials or weeds with rhizomes) should be targeted before organic practices are introduced. It is important to remember, though, that weeds are commonly an indication of a soil fertility imbalance or a structural problem in the soil: these problems must be remedied if their recurrence is to be prevented.

The first stage in the planning process involves information collection. Armed with as much information as possible, a farmer will be in a better position to make informed decisions and plan the conversion strategy. Information can be obtained from a variety of sources:

- successful organic (and conventional) farmers
- extension and research staff employed by government departments
- state organic organisations and the Organic Federation of Australia



Note: HACCP denotes 'hazard analysis critical control points'.

Figure 3.2 How far away am I from being ready to apply for organic certification?

- certification organisations
- organic consultants
- organic (and conventional) producer groups
- books and other publications
- crop and market forecasts
- organic wholesalers, retailers and exporters
- short courses and workshops—for example, Integrated Pest Management courses run by the NSW Department of Primary Industries
- agricultural research and development organisations—for example, the Rural Industries Research and Development Corporation
- the internet
- universities, agriculture colleges and TAFE colleges—especially their libraries
- organic (and conventional) farmers' newsletters—for example, NSW DPI's *Vegiebites Newsletter* and journals and papers such as *Acres Australia* and *Good Fruit and Vegetables*
- field days, agricultural trade shows, conferences and workshops.

This list is by no means conclusive, but it offers a good starting point.

When seeking information, people planning to convert to organics should not limit themselves to 'organic' networks. Much of the information available to conventional farmers is equally relevant to organic practitioners (and vice versa), particularly as conventional agriculture investigates ways of reducing reliance on chemicals.

Important information to have is a copy of the organic production standards. Each certifier has its own standard, which is available on-request. Some certifiers' standards are on their website. The standard adopted will depend on the certifying organisation. The certifiers' standards are based on the National Standard for Organic and Biodynamic Produce, which sets out the minimum requirements for production, processing and labelling of organic produce. The Australian Quarantine and Inspection Service administers the national standard and audits each approved certifying organisation to ensure it complies with the requirements of the national standard, the Export Control (Organic Produce Certification) Orders 1997 and importing countries' requirements. The national standard can be viewed on the AQIS website.

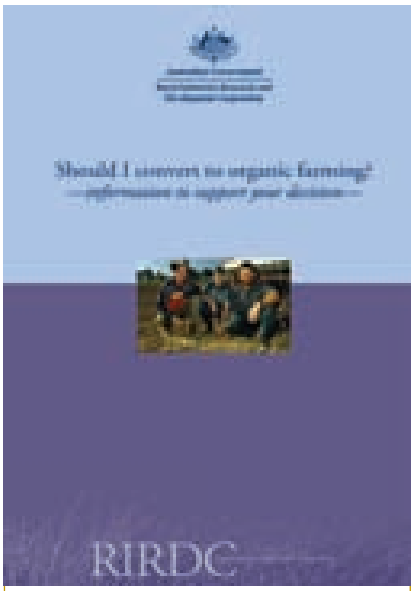
3.3 Conversion and certification

'Conversion' refers to the physical and biological changes the farmer and the farming system must make in order to comply with organic standards. 'Certification' refers to the formal process of assessment designed to lead to accreditation of the farming system as compliant with organic standards. Before going down the conversion path, farmers should ask themselves the questions posed in Figure 3.2.

3.3.1 Conversion planning

Converting to organic farming is not a short-term project, and there are no fixed methods for doing it. Each farm unit is a unique system, and successful conversion requires careful assessment of the resources available and the interactions between components of the system.

A degraded resource base and economic pressures resulting from previous land use can constitute the biggest constraints to successful conversion, and more specialised and intensive farms will generally take longer to convert. These systems require more time and effort to reintroduce diversity. The conversion process calls for a high level of commitment and often entails financial risk. Furthermore, there is little in the way of detailed information and advice about how to embark on the venture.



Should I Convert to Organic Farming? – Information to support your decision. By Viv Burnett, Robyn Neeson & Dr Els Wynen
Provides information on organic production to broadacre grain farmers to help them with the organic conversion process. Discusses the inadequate provision of information to farmers on organic production, and the relative isolation (geographic, information support) of farmers who wish to convert their farms. RIRDC Pub. No. 05/084. $16

Basically, the conversion process begins with personal conversion—attitude and approach. It is then important to develop a planning framework. Often called an 'organic management plan', the framework accommodates changes in production methods and the potential financial consequences and outlines strategies for continued adherence to organic standards. It should also set out the steps to be followed during conversion and a time scale over which the conversion will occur. Preparation of such a plan is an essential pre-certification activity.

3.3.2 Developing an organic management plan

When developing an organic

management plan, the following questions should be borne in mind:

- *How much, and over what time frame, will I convert?* It is a good idea to initially use only part of the farm to trial organic methods. A drawback is, however, that this might not allow for suitable rotations or provide the scale required for necessary adjustments in techniques and machinery. On the other hand, converting only part of the farm might allow for better financial stability if yields become depressed. Perhaps, too, it is worth trying organic production of just one commodity grown on the farm, although this could entail more work—for example, segregating organic and conventional produce.

  Under organic standards, the growing of organic and conventional produce on the same farm is referred to as 'parallel production'. The standards prohibit production of the same crops (or livestock) organically and non-organically on the same farm where the crop (or livestock) products are not visibly different. For example, it is not permitted to grow an organic crop of Rosella wheat and a conventional crop of Janz wheat on the same farm, but it is permitted to grow organic Rosella and conventional oats, provided all sources of contamination have been considered.
- *What are the potential sources of contamination and how will I overcome them?* Organic standards require that the producers implement a process for documenting and monitoring the potential for contamination from substances and practices that are not permitted and that strategies be introduced to avoid these risks.

  A system similar to HACCP—hazard analysis critical control points—should be considered. Any risk assessment requires asking, at each point in the production process, four further questions:
  - What are the potential sources of contamination during the production, harvesting, storage, transporting and processing of the crop or livestock?
  - Which of these contamination risks is significant and likely to occur if not properly managed?
  - What must be done to keep these risks at an acceptable level?
  - What records or evidence will I need to demonstrate that I have controlled the hazard?

  If parallel production is practised then harvesting, sowing, transport and processing equipment must be thoroughly cleaned before organic produce is handled. Storages for organic and conventional produce must be separate, and there must be a strong system of traceability.

  Additionally, external sources of contamination—such as over-spray from adjoining properties and contamination of watercourses running through the organic land—should be identified. The use and sources of external inputs such as seed, fertiliser and livestock feed, even if they are organic, must also be recorded.
- *What rotations should I implement?* When making decisions about rotations, it is important to consider the implications of each crop for subsequent crops in the rotation. The potential for pests and diseases, weed management, fertility management and livestock requirements must also be taken into account and be balanced against what will be profitable for the farming business. Production decisions must be viewed against the goal of optimising the economic return. Rotations must be flexible, too. One organic producer has said he would select a crop for a rotation only if it offered at least three benefits—for example, an economic return, soil structure (or nutrition) improvement, and a pest and disease break (Whittacker, pers. comm., November 1997).
- *Is my farm layout suitable?* Now is the time to consider the appropriateness of the farm's layout and how it will facilitate organic conversion. Paddock size, fencing, irrigation layout, the location of watercourses and wetlands, the presence of windbreaks, topography and soil types are all relevant.
- *Do I have suitable equipment and farm structures?* Conversion to organic management could necessitate modification or replacement of existing farm equipment and structures. Specialised sowing and weed management equipment might be needed; sealed storages might have to be built to allow for carbon dioxide disinfestation of produce; refrigeration units could be required to control post-harvest insect pests and diseases.
- *Do I have a recording and monitoring system?* Keeping records of crop production, cropping history, soil tests, livestock movements, pest and disease management and crop sales will facilitate monitoring of the impact of management practices and the changes that have occurred during conversion. Certifiers will ask for some

information—such as details of crop yields and sales—as part of the certification contract.

- *What financial factors should be considered?* The capital investment required for changes must be taken into account; this could include, for example, livestock housing, machinery, storage facilities such as coolrooms, and facilities for processing, packaging and marketing of produce. A viable marketing strategy should be established before proceeding with the organic management plan. Marketing options—including the availability of markets, the premiums offered (generally none for in-conversion produce) and marketing alliances—and value-adding potential all need to be assessed.
- *How do I start?* Start slowly. Gain experience with new crops and techniques and the potential output of the system. Start with a couple of paddocks entering the rotation for a couple of seasons. Then other paddocks can be brought in and the original paddocks can progress to later stages of the rotation. In this way the original paddocks are always a couple of years ahead, and mistakes learnt will not be repeated. Most importantly, record observations and redesign the conversion plan each year to take into account experiences with each paddock.

3.3.3 Certification

Consumers now recognise a certified organic product as their best guarantee that the product was in fact produced using organic practices. This is particularly important to consumers with health concerns.

Organic retailers and wholesalers generally will not buy uncertified produce.

The certification process involves having the farm and the farming methods examined in order to confirm that they meet the certifier's standards for organic farming. The certifier's standards cover all the requirements of the National Standard for Organic and Biodynamic Produce. Since January 1993 exports of organic produce have been required to meet the national standard, which sets out the minimum requirements for production, processing and labelling of organic produce and requires that all exporters, as well as producers and processors, be certified with an accredited industry organisation.

Seven organisations are currently accredited by the Australian Quarantine and Inspection Service to inspect and certify organic producers. (They are listed, along with their contact details, at the beginning of Appendix A.) Each certifier has standards that must be complied with in order to meet the requirements of the national standard.

Certification ensures the integrity of the organic product 'from paddock to plate', providing a guarantee to consumers. It also protects the interests of genuine organic producers in maintaining and increasing their market share. Trade practices law imposes severe penalties for passing off non-organic produce as organic.

There appears to be considerable potential for exporting Australian organic produce. Producers and exporters need to be aware that a certification program must cover any treatment, preparation and packaging of the organic product before export. All exporters must be approved for this purpose.

Domestically, the market for organic produce has expanded. The National Standard for Organic and Biodynamic Produce does not have legal standing within the Australian domestic market. Following a request from Australia's organic industry peak body, the Organic Federation of Australia, Standards Australia, Australia's peak standards body, has agreed to proceed with the development of a new Australian Standard for organic produce. The current National Organic (export) Standard is being considered as a basis for the development of the Australian Standard.

Levels in the certification process

Full certification is generally granted following three consecutive years of organic management. Some certifiers' standards refer to three levels in the certification process—'pre-certification' (also known as 'pre-conversion'), 'in-conversion' and 'organic'. Organic standards must be adhered to during *all* levels, each level usually being a reflection of the amount of time or degree to which an organic system has been implemented.

Producers must be involved in an accredited organic inspection system for a minimum of 12 months before receiving any formal acknowledgment that their product is produced using organic principles. The 12-month pre-certification period does not begin until a formal application to the certifier has been made and a statutory declaration and farm questionnaire have been completed and submitted.

Following the 12-month pre-certification period—provided organic standards are adhered to—the certifier will issue the producer with a contract and a certificate of certification. This allows the producer to label and market products as 'in-conversion'. The in-conversion period generally lasts for a further two years, after which full organic status (with label) is issued.

No label is issued during the pre-certification period.

If the decision is made to proceed with certification, a completed application form, along with the required fee, should be sent to the certifying organisation. The certifier then asks for the completed statutory declaration and questionnaire describing the products for which certification is sought and the management practices currently used on the farm.

Inspection

Once the application has been made and the certifier determines that an organic system is possible—based on the information provided in the statutory declaration and questionnaire responses—an inspector contacts the applicant to arrange an inspection time.

The inspection usually takes two to four hours but can take longer, especially on larger properties. The inspector goes through the application and statutory declaration with the farmer and asks questions. Farmer and inspector together examine the farm, the machinery and the livestock. The inspector might take soil or product samples to test for chemical residues; problem areas could be old chemical storages or chemical disposal areas and old spray application equipment.

The inspector then makes an overall assessment of the property and its management. A certification review committee considers the inspector's report and recommendation. The farmer might be asked for more information, or further inspections and tests for chemical residues might be called for. If successful, the farm will be approved for pre-certification, the phase that demonstrates to the certifier the farmer's ability to manage the enterprise organically.

Following pre-certification, another inspection takes place, and if the requirements of the organic standard are met a certificate of certification is granted. The farmer is then required to enter into a licensing agreement with the certifier. From application to certification takes 12 months. At this point, the 'in-conversion' level is achieved, after which a further two years 'in- conversion' is generally required before 'organic' status is granted by the certifier.

Once a farm is certified, it will be re-inspected each year. Unscheduled inspections are also carried out as part of the certifier's obligation to meet the Australian Quarantine and Inspection Service requirements.

The cost of certification

A number of fees are associated with becoming certified. The amount and type of fees imposed can depend on the certification organisation and on the sales turnover of the producer. In general, however, around $1300 should be allowed during the pre-certification period for the application fee, inspections (2 during pre-certification), and soil and produce residue tests.

Once certified for label use, on-going annual fees are payable which includes the costs associated with annual reinspection. These are generally around $600. In addition, some certifiers place a levy (around 1%) on gross sale of organic produce when sales exceed a minimum amount.

Additional fees may be payable under certain circumstances such as for fast tracking applications, adding new acreage and / or new products, and for residue testing.

Some certifiers offer a scheme for small growers, where local producer groups can apply for certification at a reduced rate. The typical fee per producer is around $800 pre-certification, with annual fees of around $400 once label use is approved.

Some certifiers also employ multi-skilled auditors, who can carry out other audits such as HACCP (hazard analysis critical control points) for clients.

How to stay certified

To comply with and retain organic accreditation, farmers must uphold the national standard. Any breach of the standard—such as use of a prohibited substance—will result in temporary or, for continued non-compliance, permanent de-certification. Under the national standard inputs such as fertilisers and substances for pest and disease control are classified as 'permitted', 'restricted', or 'non-allowable'.

Regardless of the type of input, its use must be recorded in the farm diary. If for any reason a non-allowable input is used, this use must be recorded and the certifier notified immediately. Only after the certifier is satisfied that organic management has been re-applied will it be possible to sell the produce in question as organic.

Continuing certification calls for good record-keeping. During inspections the inspector will want to see these records. This helps verify that management has been in accordance with the standard. Although it is not compulsory, adoption of a system for monitoring risk—such as HACCP—is recommended.

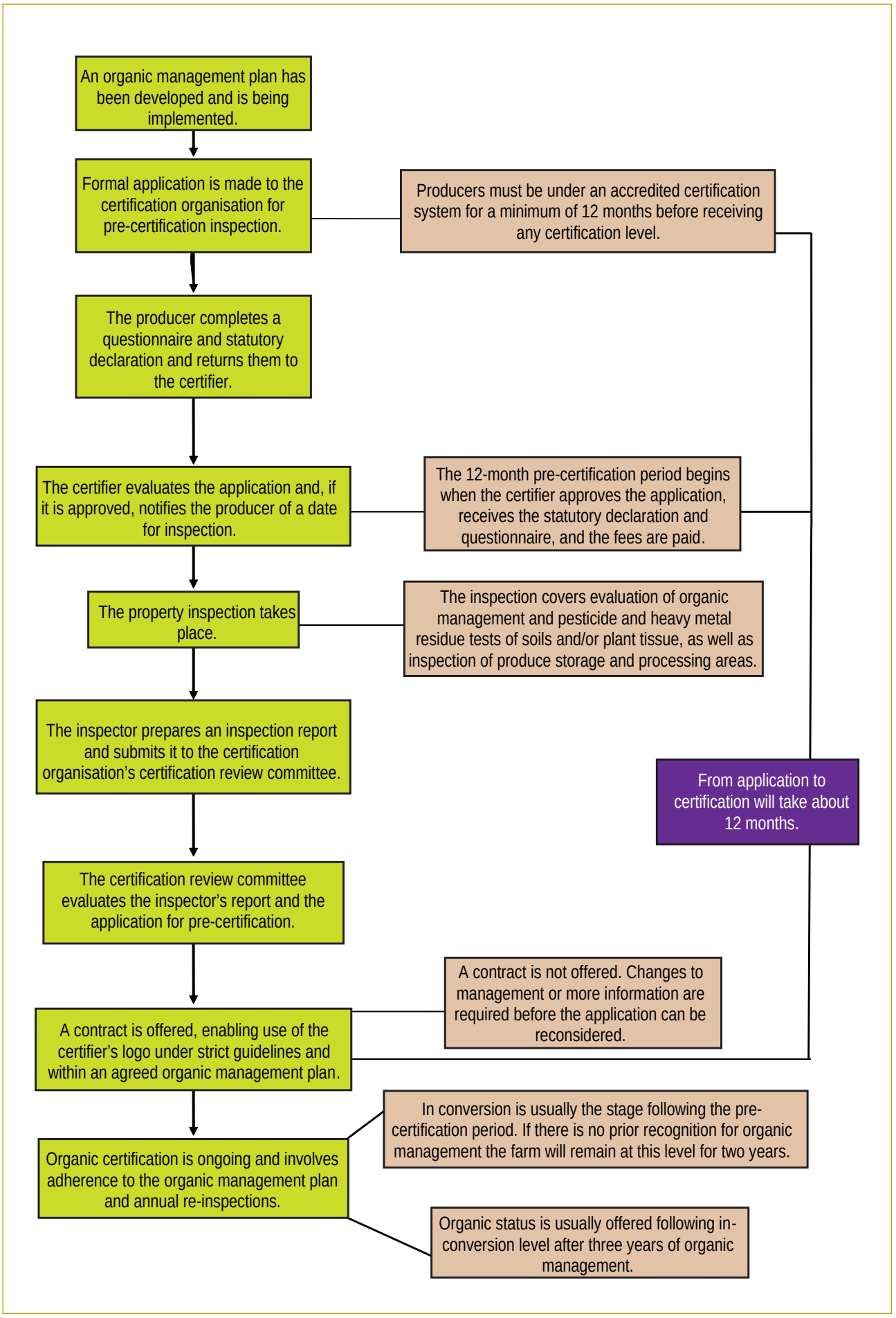


Figure 3.3 The certification process

4. Organic vegetable production

4.1 Farm selection and establishment

Successful production of organic vegetables can be very dependent on site selection. Apart from all the obvious reasons for choosing a site—suitable soils and climate, a plentiful supply of good-quality water, access to labour, transport and markets, and so on—the site should be relatively free of the pests and diseases of the crops the producer hopes to grow. For example, there may be greater risks associated with growing organic vegetables in an area where large monocultures of similar crops are grown or in higher rainfall areas, where pests and disease may be more prevalent. If processing is an option, then access to a certified processor would be a consideration.

Starting small is usually a good idea. This helps to minimise risks and allows for developing the requisite skills. Successful organic vegetable production relies on establishing a sound rotation plan; this might mean reducing the scale of the area under commercial production and putting land aside for green manure cropping. This land is then brought into production in a subsequent rotation. Rotation planning and design are discussed in Section 4.2

4.1.1 Soil and crop nutrition

Most vegetables prefer a well-drained loam or clay–loam soil with a pH of about 6.0 to 6.5. A thorough mapping of soils on the site should be done in order to determine if soil nutrition or the soil structure needs attention. Some adjustment will most probably be necessary before planting, in keeping with the crop's nutritional requirements. The soil should also



Field days highlight research findings and enable organic farmers to gather new information. Organic spelt field day at NSW DPI's Organic Research Site, Yanco.

be tested for pesticide residues and heavy metal contamination: unacceptable levels could exclude produce from organic certification or could exclude the growing of particular crops, such as root vegetables. See Section 4.4 for information about optimising soil fertility for organic vegetable production.

Compost is an essential nutritional input for an organic vegetable farm, so it would be an advantage to have access to a local source of compostable material. This could include animal manures and crop waste from other agricultural enterprises, but these materials would have to be free of excessive pesticide and heavy metal residues. Most certifiers prefer that on-site composting facilities be developed. An area of the farm should be set aside for compost production—well away from watercourses and dams to avoid pollution.

4.1.2 Pests, diseases and weeds

Before planting, it is essential to carefully develop planting and crop rotation strategies in order to avoid or reduce the risk of losses resulting from pests, diseases or weeds.

If a crop is known to be susceptible, planting into a site that has a known pest or disease history should be avoided. Similarly, weedy areas near crops, which can act as reservoirs for disease-carrying pathogens and crop pests, should be managed or avoided. Other environmental factors, such as local climatic conditions, should be also considered; for example, a site a few kilometres inland may be at less risk of infection from fungal disease than one in a higher rainfall or more humid area.

Starting production with a relatively weed free site is a distinct advantage. Sites that are heavily infested with problem weeds—particularly perennials such as couch grass, kikuyu and nut grass—should be avoided or the weed thoroughly controlled before planting. Some weeds are indicators of soil problems such as poor drainage or an imbalance of nutrients and can be brought under control over time by modifying the soil condition.

Control of noxious weeds is a legal requirement. Local councils and state and territory agriculture departments can provide details of weeds that are declared noxious. Similarly, if a producer intends to grow vegetables in a fruit-fly exclusion zone, strategies must be developed for dealing with a possible fruit-fly outbreak.

4.1.3 Water

A large, reliable water supply must be available, and it is essential to ensure access to it by confirming this with the relevant authority. The water should be tested to determine its suitability for irrigation; it should also be tested for chemical contamination, particularly if the source comes via an adjoining (non-organic) property—for example, from a creek, river or irrigation channel.

4.1.4 Proximity to non-organic neighbours

Although proximity to non-organic neighbours is not the deciding factor when choosing the site of an organic vegetable growing enterprise, it is important to determine the potential for chemical contamination from those neighbours. It is advisable that organic producers approach their neighbours and explain that they are organic growers and that they risk de-certification if chemical contamination of their produce occurs. The New South Wales *Pesticides Act 1999* offers some legal protection against pesticide contamination.

If there is potential for contamination, organic producers are required to incorporate non-certified buffer zones between the certified area and adjoining properties. Buffer zones can consist of windbreaks, wildlife and insectary corridors, or uncertified cropping areas. Properly selected and located, zones of vegetation add to the biodiversity on a farm and attract birds and other beneficial species that help control pests.

4.1.5 Transport

Access to reliable transport is essential for moving fresh produce to market. The transport might need to be refrigerated if highly perishable crops are grown, and transport operators should be made aware that the produce is organic and that it must be isolated from conventional produce to minimise the risk of contamination.

4.1.6 Labour

Vegetable production is usually a labour-intensive enterprise—and particularly so for an organic vegetable enterprise. Some estimates suggest that one person can efficiently operate a 1-hectare mixed organic vegetable enterprise. Access to additional labour should, however, be considered, especially during peak harvest periods and for any extensive hand-weeding operations. If on-farm value-adding is done, extra labour will almost certainly be needed.



A large, reliable water supply must be available

4.1.7 Equipment

Many successful larger organic vegetable enterprises use a range of specialised equipment to help with farm operations. The equipment needed depends largely on individual situations. Most producers grow vegetables on raised beds (1.5-metre centres are common), so tractors require high clearance and a wheel spacing that suits the bed size. An extensive range of farm equipment is available to market gardeners, although some of it—particularly equipment used in weed management—is expensive or hard to obtain in Australia. The good news, however, is that more is being imported or manufactured locally by entrepreneurial dealers and growers. Although it might be possible to modify existing equipment, some purchases should nevertheless be budgeted for. Among the specialist equipment currently in use in Australia are flame and steam weeders and brush weeders.

Some of the most useful tools for organic farmers are hand operated. Such tools often allow for greater flexibility and accuracy under a greater range of conditions. For larger vegetable enterprises, an excellent reading resource is *Steel in the Field: a farmer's guide to weed management tools* (Bowman 1997), which provides case studies of a number of organic vegetable producers and describes, among other things, their choice of equipment, the equipment's uses, its compatibility with other equipment, and the suppliers. Appendix A lists a number of equipment suppliers.

4.1.8 Monitoring performance

Record keeping is essential and is a requirement of certification compliance. Ideally, all growing beds should be numbered, and records should be kept of crops grown, weed, pest and disease incidence and control measures used, successes and failures, soil analysis results, green manures, fertilisers and other inputs applied, and weather data. Information should be recorded immediately after an operation is completed.

4.2 Designing the rotation

Organic crop agronomy differs according to the growth cycle of the crop species in question. These species can be broadly classified into three production groups:

- perennial—permanent planting, often with a dormant 'non-growth' period. An example is asparagus
- broadacre annual—annual growth cycle; extensive longer rotation; may include legumes and/or green manures, cereals and livestock in the rotation. Examples are pumpkin, potatoes, beets, and carrots
- intensive annual—seasonal growth cycle; intensive rotation; usually includes planting of intermittent green manure crops. Examples are leaf vegetables (for example, lettuce and Chinese greens), tomatoes and brassicas (for example, broccoli).

Organic vegetable systems are by no means limited to these three systems. For example, perennial species such as asparagus can be interplanted with annual vegetables or herbs.

These systems are further influenced by the system design. A number of aspects of design need to be considered:

- the rotation sequence (temporal), where crop choice and the timing of operations are considered
- the layout within a rotation (spatial), where row spacing, sowing density and intercrop spacing are considered to afford optimum resilience to pests, diseases and weeds and to facilitate operations such as harvesting and cultivation.
- the relationship of the crop to other natural features on the farm. For example, location and design of shelter belts and insectaries to encourage the build-up of natural predators.

These design considerations greatly affect a producer's ability to effectively manage pests, weeds and diseases organically.

4.2.1 The rotation sequence

Perhaps the most crucial management decision for an organic vegetable farmer is the design of the cropping rotation, which should meet the farmer's production and financial needs while also implementing sustainable agricultural practices.

The choice of vegetable crops and their relationship with one another, with fertility building and with pest and disease–breaking crops such as pastures and green manures are all factors that must be considered when deciding on the rotation design. Other factors that should be taken into account are the market for the chosen crops, the available resources (for example, labour and equipment), the economics of the rotation and, if they are to be a part of the rotation, the role of livestock.

4.2.2 Rotation rules

Although there are a number of rules that should be followed when designing a rotation, flexibility is a central consideration: there is no point sticking to a planned rotation if, for example, the market for a particular crop has slumped. When choosing crops for a rotation it is a good idea to have a number of uses in mind—say, processed or fresh—and in such a situation careful choice of variety is crucial. Organic certifiers might stipulate that in any three-year period at least one year should include a green manure crop, leguminous crop or pasture phase. This might not be required if compost is regularly applied for primary fertility building or where livestock are incorporated in the system.

Generally, however, the following rules should be applied:

- *Avoid repeat cropping with the same species*. For crop rotation to be effective, vegetables belonging to the same plant family should not be planted in the same location for two or three years, or perhaps even longer if soil borne diseases are known to exist. This avoids the potential for pest and disease build-up. Knowledge of which insects, diseases and weeds may cause problems, their life cycles, and the conditions that favour their development is essential, to help plan the rotation and to develop management strategies to avoid or overcome problems.
- *Crop rotation and weed control*. Some crops and cropping conditions seem to encourage particular weed problems. These problems can occur in the current crop or in the next season's crop. It is important to note and record these weeds, particularly during the early planning stages, so that it is possible to plan their control when those conditions recur in the rotation. Some crops and weeds can affect the growth of subsequent crops or

weeds by exuding a chemical, a phenomenon known as allelopathy. Allelopathic influences can be both an advantage (if they affect weeds) or a disadvantage (if they affect the crop).

- *Precede soil-depleting crops with soil-replenishing crops*. A rotation should generally consist of soil-depleting and soil-replenishing crops. Legumes can provide nitrogen for subsequent crops. Other crops, such as those with deep tap roots, have the ability to exploit a greater area of the soil nutritive reserve. Turning in refuse from these crops will help recycle deep nutrients for use by shallow-rooted crops. Crops with fibrous root systems are also important for nutrient exploration. Some crops are chosen on the basis of their ability to add to soil organic matter. With green manure crops, the aim should be to have a range of species that fulfil all of these requirements.

  The composition and timing of incorporating a green manure crop can be designed either to supply essential nutrients (if ploughed under when young or, for legumes, at early flowering) or to boost organic matter and improve soil structure (if allowed to produce maximum crop biomass before being ploughed in). Table 4.1 shows two possible green manure mixes, their cost, and their biomass contribution.

  Crops having higher nitrogen requirements should follow green manure crops. These include crops such as lettuce and sweet corn, which have a shallow, fibrous root system. These would then be followed in the rotation by flowering crops such as broccoli and cauliflower, which have lower nutritional requirements, and then by a deeper rooted fruiting vegetable such as pumpkin. The final crop in the rotation would be a root vegetable: these have the greatest ability to exploit the soil profile for remaining nutrients. This could then be followed by two green manure crops—one to increase soil organic matter (for example, an oat-based crop) and the other legume based—to precede the start of the next vegetable rotation. Alternatively, a single green manure crop and compost could be applied.

  Incorporation of a green manure crop in the rotation does not preclude supplying additional nutrients before or during a vegetable crop's growth. Soil and leaf analysis will help to determine these requirements. Section 4.4 discusses crops' nutritional requirements in greater detail.

- *Use the root physiology of crops to help improve soil structure*. Some crop species—such as sunflowers—have extensive and penetrating root systems. These can also be incorporated in the rotation, reducing the need for primary tillage.

Table 4.1 Two possible green manure mixes: cost and biomass contribution

Field pea mix	Vetch mix
50kg/ha field pea (Dundale)	30kg/ha vetch (Popany)
20kg/ha oats (echidna)	20kg/ha oats (echidna)
1.4kg/ha fodder mustard (Winfried)	1.4kg/ha fodder mustard (Winfried)
60kg/ha faba beans (mixed)	30kg/ha faba beans (mixed)
Biomass yield/ha: 48.450 tonnes	Biomass yield/ha: 39.967 tonnes
Sowing rate: 131.4kg/ha (total mix)	Sowing rate: 81.4kg/ha (total mix)
Cost of mix: $159.0/ha	Cost of mix: $94.3/ha

4.2.3 Spatial design considerations

Row and inter-row spacing, the number of crop rows per bed, and interplanting with other species to act as insectaries or trap crops are some of the spatial design considerations when planning a cropping phase.

Weed management

Weeds grow best where there is minimal competition—for example, where there are gaps in a crop stand. Because weeds are better competitors, they will occupy these sites rapidly. Several practices can reduce the potential for weeds to invade a site:

- decreasing the inter-row spacing—that is, increasing the crop sowing rate
- decreasing the distance between rows or beds
- increasing the number of crop rows on a bed
- growing a competitive crop or a crop that is readily cultivated—for example, pumpkin and potatoes.

The aim is to close the crop canopy as quickly as possible. In the case of crops that never establish a competitive canopy—such as onions and, to a lesser extent, carrots—other strategies are needed. Of course, any strategy that changes crop or row spacing must be compatible with the available machinery and equipment. Experimentation might be needed in order to determine the optimum spacing for each crop. Increasing the sowing rate can affect the total yield and the size of the product—for example, the head size of cauliflowers and the bulb size of onions.

Pest management

The crop spacing and its relationship with other crops

can influence the occurrence and dispersal of pests and their predators. Insectaries (to provide food sources and thus encourage beneficial predatory insects) and trap crops (to provide a preferred food source for the pest) are often interplanted in strips or planted as a border surrounding the main crop. Research in the United States has shown that substantial numbers of beneficial insects can move up to 113 metres from insectary hedgerows into adjacent vegetable crops. Research into spatial design for insectaries and trap crops is increasing, but there is as yet little information available about optimal design for the management of specific pest and predator species.

Understanding a pest's ecology and dispersal characteristics will help when designing cropping layouts. For example, to limit the spread of aphid-transmitted virus, crops planted later can be planted upwind of fields planted beforehand. In New Zealand beetle banks have been successfully used around crops to prevent pests moving into the crops. Some planting layouts can also confuse pests and thus reduce egg laying or dispersal.

4.3 Variety and crop selection

Market suitability, physiological characteristics, pest and disease resistance, seed or seedling availability, and environmental suitability are all considerations when determining what variety of crop to plant. Since 31 December 2003 it has been a requirement of the National Standard for Organic and Biodynamic Produce that the chosen variety be obtained from organically certified seed or seedlings. The variety should also be popular in the marketplace, be high yielding, have good pest and disease resistance, and have good seedling vigour and canopy development



Market research is essential for determining which vegetables are popular with consumers. (Organic products in a Woolworths supermarket.)

in order to smother weeds. Some varieties have features—for example, hairs or a rough surface—that make them unattractive to pests.

4.3.1 Market suitability

Market research is essential for determining which vegetables are popular with consumers. Contact organic wholesalers, retailers and exporters and find out what is required and when it is required. Some types of vegetables might be undersupplied at particular times of the year, and it might be possible to fill that seasonal gap. Restaurants or caterers might want specialty vegetables—for example, 'mini' vegetables. Local markets or farm-gate sales might be a possibility, in which case growing a broad range of popular lines could be the best option. A vegetable processor is another possibility: organic baby food is being marketed by a number of processors in Australia and elsewhere. A study by the Queensland Department of Primary Industries found that there is an export market for frozen organic vegetables (Lakin & Shannon 1999).

Generally, there are preferred cultivars for processing and for the fresh-food market; this should be researched. Processors will probably have their own requirements, which could include variety, timing and quantity of supply, shape, or specific composition requirements such as the percentage of soluble solids in the product.

4.3.2 Environmental suitability

Once the decision has been made about what to grow, the next step is to choose a suitable cultivar. Do some 'local' research: contact the local agriculture department, producers and home gardeners to find out what performs well in the area. Soil type and seasonal characteristics such as day length and temperature range all influence what cultivars can be grown and when they can be grown. It may be possible to modify environmental factors to protect or change the maturity date of crops: crop (or row) covers and glasshouse production can achieve this.

4.3.3 Pest, disease and weed resilience

Among the variety features that will give an organic crop an advantage are inherited disease and pest



Green manure crops of oats, faba bean and vetch, NSW Department of Primary Industries organic demonstration site, Yanco. Photo: NSW Department of Primary Industries.

resistance, seedling vigour, broad leaves (to shade out weeds) and 'hairy' fruit (as in some types of squash) to deter pests. Varieties selected on the basis of their maturity date can be planted to avoid periods of high pest and disease incidence.

4.3.4 Seed and seedling availability

Organic certification standards require that first preference be given to planting organically raised seeds or seedlings.

Since 1 January 2004 this has been a requirement of the National Standard for Organic and Biodynamic Produce. An industry database of producers and suppliers of organic seed and seedlings is being developed.

Open-pollinated and non-hybrid varieties are also preferred but are not essential. Genetically modified (transgenic) cultivars are not permitted in organic systems.

Care should be taken to ensure that the seed has acceptable germination. A few seeds planted in a pot before sowing will give an indication of the germination percentage. Seed must not be treated with pre-sowing chemicals.

4.4 Soil fertility and crop nutrition

Organic farming starts with the soil. The organic farmer's primary aim should be to provide crop and animal nutrition by implementing practices that nurture the soil, stimulate soil life, and conserve nutrients. This involves developing both long-term and short-term strategies to improve soil health and to supply crop nutrition.

4.4.1 Organic soil conversion

Organic conversion is not just about replacing a high–chemical input system with a no-input, or every 'alternative' input, system. The organic soil-building process goes through three critical stages, which can be referred to as the 'adjustment phase', the 'comfort phase' and the 'maintenance phase'.

The adjustment phase

The adjustment phase involves developing a system that reduces the crop's reliance on artificial chemicals. This could be likened to going 'cold turkey' for farming systems that are heavily dependent on chemical inputs. During this phase some farmers have observed that crop yields can decline as the system converts from a chemical to a biological one and is starved of its regular 'fix' of readily available, chemical fertilisers.

The length of this preliminary soil-building process depends largely on the soil's pre-existing condition and fertiliser history. The phase involves increasing biological activity by providing optimal soil conditions. The challenge for organic farmers is to develop and adopt a cost-effective strategy that encourages and builds biological processes in the soil while maintaining optimal plant nutrition. In addition to standard organic practices—such as planting legumes and green manure crops and applying compost and rock dusts—commercial organic fertilisers, seaweed, fish emulsion, sugar solutions and microbial preparations are applied to stimulate soil biological activity and supplement plant health.

The comfort phase

The comfort phase coincides with an increase in biological activity and a corresponding release of previously 'locked-up', or unavailable, nutrients. It is during this phase that optimal crop yields are reached. Organic farmers need to be careful not to over-fertilise during this phase. This is more likely to occur in intensive horticulture systems, where application of compost and green manuring are common practice. Over-fertilisation usually manifests itself through crop physiological problems and an increased incidence of pests and diseases.

Farmers should also be aware that a running down of the nutrient reserve can also occur if the soil system is not being monitored properly. Usually, organic farmers regularly monitor soil nutrient levels. Soil and plant tissue testing allows nutrient requirements to be tracked, thus avoiding 'overfeeding' or 'underfeeding' the soil system.

The maintenance phase

Research has shown that some organic systems have, over a relatively long period, experienced a decline in soil nutrient reserves (Small et al. 1994; Penfold et al. 1995). This could be attributed to long-term drawing down of nutrients during harvesting of crop or (less so) livestock products and through natural processes such as leaching. In Australia this has been particularly evident in broad-acre cropping and livestock enterprises where a phosphorous deficiency has been found. This has implications for cereal and legume crops: phosphorous deficiency in legumes adversely affects the plant's ability to fix atmospheric nitrogen in root nodules; nitrogen fixed by legumes is an essential nutrient in subsequent crops in the cropping rotation.

Preparing a nutrient budget by reconciling inputs and outputs and correlating this with regular soil tests and crop performance can help organic producers track the performance of the annual soil nutrient cycle.

Increasing biological activity

Organic conversion begins with a process that encourages increased activity by microbes and arthropods in the soil. The elemental composition, structure and organic matter content of the soil need to be favourable if biological activity is to be increased.

Biological activity in the soil begins with the breakdown of organic matter. During the decomposition process the organic molecules in organic matter are either broken down into simpler organic molecules that require further decomposition or converted into mineralised nutrients. Organic farmers supply organic matter through incorporation of green manure crops and crop refuse and the addition of compost.



Lucerne is undersown eight weeks after the emergence of sweet corn. Following the corn harvest, the lucerne growth accelerates rapidly. NSW Department of Primary Industries organic demonstration site, Yanco. Photo: NSW Department of Primary Industries.

The use of bio-indicators is becoming increasingly important as a way of assessing soil health. Pankhurst et al. (1997) review how soil organisms and biotic processes can be used as indicators of soil health. A variety of techniques can be used for assessing biological activity, among them measurement of soil microbial activity based on the soil's carbon dioxide respiration, DNA testing to determine the diversity and abundance of micro-organisms present, and an 'in-situ' technique based on measuring the tensile strength of a cotton strip that has been buried in the soil. Commercial laboratories offering services to assess soils for microbial status are now becoming more common in Australia.

Green manuring

Green manure crops are grown specifically for cultivation back into the soil in order to build up organic matter and nutrients and to stimulate biological activity. The type of green manure crop and the stage at which it is turned in determine the amount of organic matter or nutrients returned to the soil. A lush, actively growing legume sward (of vetch, faba beans or lupins, for example) contains large amounts of nitrogen (50–140 kilograms of nitrogen gain per hectare) that is released to the soil upon cultivation. The same crop, when allowed to mature, contributes more organic matter but less available nitrogen. If a soil is low in organic matter, a green manure crop that increases organic matter (for example, oats) is desirable.

Green manures can also act as 'break crops' to reduce the carryover of pests and diseases in subsequent crops in the rotation. They are an essential component in intensive organic annual cropping rotations.

Nitrate leaching following the incorporation of a green manure crop can occur when rainfall exceeds evaporation, resulting in net drainage. There is some evidence that nitrate leaching might be less under an organic system than under a conventional system (Lampkin 1990). Nitrate leached below the root zone is effectively lost from the system. Rotation design within the organic system must take into account the need to minimise large nitrogen losses following ploughing in of the green manure crop. Early establishment of a cereal crop immediately after incorporating the green manure has been shown to be one of the most effective ways of reducing nitrate leaching.

Some organic farmers apply foliar sprays of sugar, molasses or compost teas to green manure crops prior to turning the crop in. This is thought to provide additional energy for micro-organisms, enabling a more rapid breakdown of green matter prior to planting the next crop.

Undersowing crops

Undersowing crops—for example, barley with the grass or clover pasture that will follow in the rotation in the succeeding year or almost any leguminous crop—is central to organic systems. The practice has been shown to have beneficial effects on the diversity and abundance of insect species (Vickermann 1978). Other benefits are the potential for higher protein content in cereals undersown with a legume as a result of a small net nitrogen gain, improved weed suppression, improved pest and disease control, and establishment of that very important clover-based pasture (Lampkin 1990).

Permanent swards and pastures

In both livestock and cropping enterprises legume-based pastures provide the system's main nitrogen input and livestock largely recycle other nutrients. In orchards, permanent swards, or sods, are sometimes planted between the rows and are the preferred method of inter-row management because the soil ecosystem remains undisturbed. This favours the development of plant roots, soil microfauna and flora, worms and mycorrhiza and helps retain good soil structure.

A mixture of deep-rooted and shallow-rooted species increases the potential for gaining access to soil nutrients; for example, in organic pastures herbs such as chicory, plantain, yarrow and caraway are often added. Ideally, an orchard sod consists of a range of perennial plant species. Grasses such as ryegrass and fescue are efficient in obtaining potassium from the soil and are able to make use of excess organic nitrogen. Legumes such as clover and lucerne can contribute 40–140 kilograms per hectare per year of nitrogen to the soil reservoir. Herbs such as plantain and chicory often have a higher mineral content and have deep roots capable of bringing up leached elements that would otherwise be unavailable to the crop.

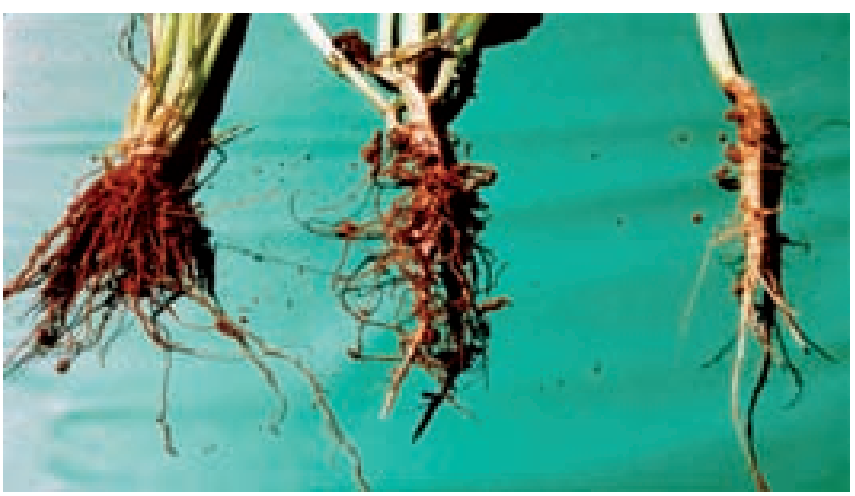
Compost

Compost is a primary source of nutrients and organic matter in intensive organic farming systems and an invaluable food source for soil micro-organisms. Compost is not widely used in Australian broad-acre organic cropping systems because sources of compost material are limited and, when available, often costly. Animal manures and crop refuse are the main ingredients of compost. Organic standards require that imported manure intended for application be composted before use.

The primary benefits of compost are that it is a more stable form of organic matter than raw waste and weed seeds and diseases are destroyed during the composting process. When manure is composted, it is easier to spread, and losses to the environment are minimised. Rock dusts and clay added to compost in small quantities can help reduce nitrogen losses from the heap by absorbing ammonia (Lampkin 1990).

Many recipes and techniques are advocated for composting. The Australian Standard for Composts, Soil Conditioners and Mulches (AS 4454-1999) defines composting as 'the process whereby organic materials are pasteurised and microbiologically transformed under aerobic and thermophilic conditions for a period of not less than 6 weeks'. The pasteurisation process is described as having 'the whole mass of constantly moist material subject to at least three consecutive days at a minimum temperature of 55°C'.

The principal aim of composting is to produce a stable humic compound. This is achieved by mixing main ingredients together in quantities that achieve a suitable carbon–nitrogen ratio. The ideal ratio lies between 25:1 and 35:1 (Lampkin 1990). Moisture content is also important and ideally should be about 55 to 70 per cent. Compost heaps should be designed to allow sufficient air access. Microbial activity quickly raises the temperature of the heap to 55°C, where it stays for a



Having a mix of deep-rooted, shallow-rooted, fibrous-rooted and nitrogen-fixing species in green manure crops increases the potential for gaining access to soil nutrients and improving soil structure. Pictured here are, from left to right, oat, faba bean and fodder rape roots. Photo: NSW Department of Primary Industries.



Compost—a primary source of organic matter and nutrients in intensive organic farming systems. Compost production at NSW Department of Primary Industries organic demonstration site, Yanco. Photo: NSW Department of Primary Industries.

minimum of three days before the compost heap is then turned (ASA standards specify a minimum of three turns) to allow for thorough mixing and a further heating of any undecomposed material.

Compost is usually applied at a rate of 5 to 20 tonnes a hectare—the higher rate on sandier soils. Some certifiers put limitations on compost rates above 20 tonnes a hectare. Soil analysis and crop requirements will help determine application rates.

Organic farmers should aim to establish on-farm composting and handling facilities, which should be sited well away from watercourses and dams. Efforts should be made to avoid run-off and nutrient loss—for example, by covering the compost windrow. A grassed buffer area downslope of the windrow will help absorb nutrient run-off. If a certified source of compost is available locally, this could be a preferred option, provided it is cost effective (include the transport costs).

Suitable equipment is needed for handling, turning and spreading the compost. This might include a front-end loader or tractor-mounted bucket for loading and turning and a manure spreader for application.

Rock dusts and re-mineralisation

Many Australian soils are leached of elements essential for plant growth. Moreover, many years of farming with an emphasis on supplying a nitrogen–phosphorus–potassium fertiliser regime, at the expense of minor elements, might have resulted in further 'mining' of some trace elements. This theory has some support: evidence suggests a gradual decline in the elemental composition of fresh fruit and vegetables since the 1940s (McCance & Widdowson 1992).

Soils with higher biological activity play an important part in increasing the availability of micronutrients. Much research has been done into the symbiotic roles of arbuscular mycorrhiza fungi in increasing phosphorus availability in plants and rhizobium bacteria and their ability to fix atmospheric nitrogen for plant use. There has, however, been little research into the role of other soil micro-organisms in improving micronutrient uptake by plants.

The re-mineralisation of Australian farming soils is a strategy more recently proposed by some soil health experts. Various techniques for re-mineralisation are gaining an increased following among farmers; they are largely based on balancing soils' cation exchange capacity and achieving a satisfactory calcium–magnesium ratio (Albrecht 1975). The effectiveness of the techniques is yet to be scientifically evaluated under Australian conditions.

Re-mineralisation involves the addition of various rock-based materials, among them reactive and colloidal rock phosphate, dolomite, limestone and rock dusts (from silicate rocks, including basalt and bentonite), as well as some commercial organic blends.

Rock dusts can be added directly to the soil or to compost heaps. Whatever the method of application, the release of nutrients from the rock dusts is accelerated by moist conditions, high temperatures and high biological activity—for example, during a green manure stage or composting. Finer particle size of the rock dust is preferred as this provides a greater surface area for micro-organisms to act on and hence a more rapid availability of nutrients to plants. Where soils have good biological activity and are subject to irrigation, the effectiveness of the mineral products can be further improved.

Rock phosphate becomes available more quickly under acidic soil conditions (a pH less than 5.5) and where rainfall exceeds 600 millimetres. Because the benefits of rock dusts are not available immediately to a crop, the dusts should be applied a few seasons before cropping. Consistent, small applications throughout the rotation should be considered.

For growers buying mineral rock dusts, it is important to note that unacceptably high levels of heavy metals have been found in some commercial products. Unlike other commercial fertilisers, rock dusts are at present not required to undergo testing or to be registered under the *Fertiliser Act 1998*. Each batch bought should be tested, or a written declaration should be obtained from the manufacturer or supplier, in order to determine whether impurities are present.

4.4.2 Improvements to soil structure

Improvements in the biological activity and cation exchange capacity of soils will generally lead to an improvement in soil structure, but this needs to be supported by

suitable cultural practices. Use of suitable machinery at the correct soil moisture, incorporation of soil organic matter, and improvement of soils using differing types of crop root physiology are techniques organic farmers use in order to develop soil structure.

Lampkin (1990) describes cultivation practices as having the greatest impact on the soil of any agricultural activity. He summarises the organic approach to soil cultivation as one that seeks to maintain soil structure and allow the soil to have vegetative cover for as long as possible within the rotation. Shallow cultivations, where only the surface layers of the soil are mixed, are an important element of this approach. Deep cultivation of dry soil is practised to loosen and aerate soil, avoiding inversion of the lower layers. Green manures or cereal crops are sown as soon as practicable following cultivation: their roots help stabilise loosened soil and minimise nitrate leaching.

4.4.3 Correcting deficiencies organically

Unseasonal weather, such as a prolonged dry spell or excessive moisture, or simply a miscalculation of crop nutrient requirements, can result in a nutrient deficiency in the crop. If this happens during a critical crop growth period, plant health can decline, predisposing the crop to pest and disease attack. A permanent yield loss could result, so it is necessary to correct any deficiency quickly. Leaf analysis is the most commonly used method of detecting deficiencies during the crop-growing period. Organic farmers use foliar sprays (such as fish and seaweed extracts) molasses, compost teas and trace elements to correct temporary deficiencies. Guidelines for foliar feeding of plants can be found on the website of the US National Sustainable Agriculture Information Service <http://www.attra.org/attra-pub/PDF/foliar.pdf>.

4.4.4 Livestock and soil nutrition

Livestock play an important part in organic farming. Crop nutrition is improved when a pasture or grazing phase is incorporated in the cropping rotation. This is common practice in broad-acre systems and in some annual vegetable production systems. Among the nutritional benefits offered by a pasture phase are nitrogen fixation through the legume component and the recycling of organic matter and nutrients via livestock manure. The pasture phase can also help to suppress pests, disease and weeds by providing a break in the disease cycle.

If well managed, poultry such as chickens, geese and ducks can provide valuable nutrient inputs as well as contributing to pest, disease and weed control. Section 2.2 provides more information about managing livestock.

4.4.5 Determining crop nutrient requirements

The availability of nutrients in the soil and the growth stage of the crop will determine a crop's nutrient requirements. Augmentation of nutrients in the soil reservoir necessitates a long-term fertility building program. Increasing biological activity and organic matter (and thus humus formation) and balancing other essential elements (for example, the calcium–magnesium balance) should be based on site-specific information collected through regular soil analysis. Soil tests are the first step to planning a soil management program.

Soil tests should be conducted regularly—particularly during the early stages of conversion—to help track the effectiveness of soil improvement and crop nutrition programs. Soil samples should be collected from all representative soils on the farm, with care being taken to map out the location and depth of sampling. A good sampling procedure is described on the NSW Department of Primary Industries website <http://www.agric.nsw.gov.au/reader/6701>. Ideally, samples should be taken in the same area and during the same environmental (temperature, soil moisture) conditions each time.

The samples should be sent to an independent, accredited soil laboratory. It is best to verify the sampling and packaging technique with the laboratory before dispatching the samples. Various levels of detail (and cost) are available with the analysis. A full analytical assessment (including an assessment of biological activity) costs from $80 to $150. Appendix A lists some accredited analytical laboratories.

4.4.6 Seasonal nutrient requirements

During conversion to organic production and during a crop's growth period additional nutrients might need to be supplied. It is important that crop growth does not falter during the growing season, and in this instance sap or tissue tests on the crop offer a method of rapidly checking crop nutrient status. Nitrogen, phosphorous, potassium and calcium are the elements most often required by crops.

Nitrogen

Nitrogen is required in reasonable quantities by most vegetables. Unlike many elements, it is relatively mobile in the soil nutrient pool. As nitrate, nitrogen is water soluble and can be rapidly leached from the crop root zone. When large amounts of organic carbon are present—for example, when straw

or crops rich in organic matter are turned into the soil—nitrogen can become temporarily unavailable as soil microbes use the nitrogen to help them digest the carbon. Nitrogen can also be lost in gaseous form, through the processes of denitrification and volatilisation.

Before planting, nitrogen is supplied through incorporation in the soil of legume-based green manures, compost, blood and bone (usually applied as an ingredient during composting) and commercial organic fertilisers. Note that in the case of leeks, chives and shallots organic animal products such as blood and bone[1] should not be applied immediately before planting because they attract the corn seed fly whose larvae will attack the planted cloves or germinating seed.

Although nitrogen mineralisation can be high—up to 900 grams a day—this might be inadequate for a rapidly growing vegetable crop. Short-season crops such as radishes and beets will most probably be able to obtain all their nitrogen requirements from a green manure crop, compost or organic fertiliser that has been applied before planting. Crops with a growing season beyond six to eight weeks will probably need additional nitrogen, applied as a side-dressing or foliar spray or, if used, by means of drip irrigation. Commonly used substances are fish emulsion, worm juice and compost teas (made from stinging nettle, for example).

Phosphorous

Although soil tests might show there is sufficient phosphorus in the soil, the phosphorus might be in a form that is not readily available. Cold, wet soils, which can limit root growth, restrict phosphorus availability. In addition, organic sources of phosphorus are less soluble than conventional forms such as superphosphate, which is treated with sulphuric acid to increase its solubility, so there is a time lag before phosphorus becomes available for the crop. Increasing biological activity improves availability, but additional phosphorus applied in small, regular doses will ensure that a reliable supply is available for crop growth. Rock phosphate, guano, fish meal and bone meal[1] (usually added as an ingredient during composting) all contain moderate levels of phosphorus and are commonly applied in organic systems. Phosphorus should be applied at least a year before cropping.

Potassium

The element potassium is needed for flower and fruit development and to improve storage quality; it is particularly important for crops such as tomatoes. Among the organic sources of potassium are compost, seaweed, basic slag, wood ash, sulphate of potash, and green sand (langbeinite). Numerous commercial organic fertiliser blends containing potassium are available.

Calcium

Calcium is needed for plant cell strength, pest and disease resistance, and post-harvest quality. The Albrecht theory of plant nutrition holds that calcium and its relationship (ratio) with cations, particularly magnesium, are critical for soil-building processes and crop growth. Like phosphorus, calcium must be applied well before planting, with regular, small doses beneficial to sustain soil levels. Limestone (naturally mined), dolomite and gypsum are sources of calcium. Dolomite is also a source of magnesium, and gypsum also contains sulphur.

Other elements

Other minor elements essential for crop growth might be lacking in the soil. Commercial organic fertilisers, compost and foliar applications of seaweed, worm liquid and compost teas can be used to remedy deficiencies.

4.5 Soil preparation and planting

Cultural management of soil in vegetable production systems is a matter of achieving a balance between the primary goal of maintaining or augmenting the level of organic matter and that of achieving an acceptable soil condition through the tillage that is required for crop growth and weed management.

Conventional intensive tillage systems generally have long-term negative effects on organic carbon levels in the soil. Conservation tillage techniques, while minimising soil disturbance and carbon loss, generally leave crop residues on the soil surface. This creates problems for organic producers who rely on tillage to manage weeds, incorporate crop residues, and aerate the soil.

4.5.1 Ground preparation

Following any preliminary soil remediation works, the soil should be cultivated to a depth that will encourage root growth and drainage. On clay soils this might entail deep ripping or deep aeration with an implement such as the Agroplow®. Growing a deep-rooted crop such as sunflower might help break up hard pans and improve drainage. Adding gypsum can also improve drainage in some soils.

Vegetables are generally grown in rows or beds, and ripping should follow this layout. Primary tillage usually involves developing a deep, friable soil, which is then formed into hills; if beds are to be used, a number of hills are combined into a bed. Further information on farming on raised beds can be obtained in the NSW Department

[1] *Precautions should be taken that the uptake of such products by livestock as part of their diet is avoided.*

of Primary Industries Agfact, *Cropping on Raised Beds in Southern NSW*, see: < http://www.agric.nsw.gov.au/reader/soil-types-structure/p1-2-1.pdf?MIvalObj=17733&doctype=document&MItypeObj=application/pdf&name=/p1-2-1.pdf>

Slowly available and soil-building substances such as compost, rock phosphate and lime are best applied before forming the beds. It is extremely important that the beds or rows be straight and the correct distance apart: otherwise, post-planting cultural operations such as inter-row weeding will be difficult. If well made, beds should last a couple of seasons before needing to be re-formed. If subsurface drip irrigation is to be used, it must be installed after bed-forming and before sowing the crop.

Green manure should be incorporated well before the crop is planted. Organic matter (in this case, the green manure crop) must first be digested by micro-organisms before any nutritional benefits become available to subsequent crops. Nitrogen is used by micro-organisms as they consume and break down organic matter, and if a vegetable crop is planted when undecomposed organic matter is still present a temporary nitrogen deficiency can occur. Some organic practitioners spray molasses, compost teas, sugar or microbial solutions on the green manure crop before incorporation, to facilitate its breakdown.

Incorporation of the green manure should be shallow, while still burying crop refuse. A bulky green manure might need to be slashed or mulched before incorporation, to facilitate breakdown. A rotary mulcher can be used very effectively to break up large amounts of crop refuse and can be adjusted to operate in the top 5 centimetres of soil.

The timing of incorporating green manures also needs careful consideration. Rapidly growing, immature green manures break down more rapidly than green manures that are allowed to mature. In legumes, once flowering begins, the vegetative growth slows, and nitrogen that has been fixed by the plant begins to be used for seed production. This is lost nitrogen in terms of the vegetable rotation, so incorporation should occur before or during early flowering of the green manure. If a mixture of species is used in the green manure, it might be necessary to forfeit some nitrogen benefit in order to ensure that there is sufficient time for the organic matter to decompose before the vegetable crop is planted. Low soil moisture can also slow the rate of decomposition. Green manures should never be allowed to go to seed (unless the seed is to be saved for future planting) since this can cause weed problems in subsequent crops.

Primary tillage can be very destructive of soil organic matter. The benefits of a green manure crop grown and incorporated before preliminary ground preparation and bed-forming can be quickly lost by excessive cultivation, or by cultivating at inappropriate soil moisture levels. Once the beds are formed, a green manure crop can be grown in situ, then mulched, and shallowly incorporated before the vegetable crop is planted. This cultivation can damage beds, so it is sometimes necessary to reshape the bed following incorporation of the green manure.

Another green manuring technique uses the residues of crops such as vetch grown in the previous season. The vegetable crop is planted into the residual surface mulch of the cover crop. The technique relies on the senescence of growth in the cover crop. The crop is then mulched down to form a surface mulch. The technique relies, however, on the cover crop dying off before the vegetable crop is planted. The growth cycle of the cover crop must be completed in time for that crop to be mowed before the vegetable crop is planted. Provided dry conditions prevail, this can be achieved for a winter-grown cover crop to be followed by late–spring planted vegetables. Late spring rains can, however, cause unacceptable delays to cover crop senescence and crop sowing. In addition, planting into the cover crop residue calls for specialist equipment. Despite these problems, researching suitable cover crops and their management as surface mulches in organic vegetable production systems is worthwhile.

4.5.2 Pre-irrigation

Pre-irrigation or rainfall before planting is advantageous: it helps germinate weed seedlings and provides a moist seedbed into which the crop can be sown. The weeds are usually cultivated out before sowing: in this case, the cultivation should be shallow and should avoid soil inversion since this would promote further germination of weeds. An effective implement is one that 'slices' under the soil, lifting and removing young weeds. It is important to avoid cultivating if rain is imminent because the weeds will be transplanted. Flame, steam and brush weeders can also be used to control young weeds. If pre-irrigation is not possible, planting should avoid soil disturbance as much as possible. Some post-planting weed control will nevertheless be required.

4.5.3 Planting

Before planting, soil tests should be done in order to determine whether additional fertiliser is needed, given the crop's known requirements. Organic fertilisers or compost can be surface applied or

banded in the crop row. The time of planting should take into account the requirements of the variety to be grown, the market 'window' and if, by delaying planting or planting earlier, potential weed, pest or disease problems might be avoided.

Since 1 January 2004 it has been mandatory to use organically produced planting material. If such material is not available, formal application must be made to the certifier for an exemption. Exemptions are granted only if it can be demonstrated that the variety in question is not available or the quality is not acceptable. It should still be possible for a commercial organic nursery to supply transplants, provided it receives plenty of notice (about 15 weeks) in order to obtain the variety and prepare the order.

Germination tests should be carried out before seed is sown. This can be done by placing a few seeds in a pot or between damp (not wet) tissue paper for a few days and recording the germination percentage. The sowing rate can be increased to compensate for reduced germination. Some seed sources are very unreliable, so it is advisable to obtain a written guarantee of the seed germination percentage and the seeds' freshness. Seed not used immediately should be placed in an airtight container and refrigerated.

Transplants should be checked for pests and any that are found should be removed before planting. A strong jet of water will physically dislodge some pests. Alternatively, they can be sprayed with an organically acceptable pesticide. The transplants should then be hardened off outdoors for a few days before being planted in the field.

Seeds or transplants?

Vegetables such as carrots do not transplant well, so seeds are the only option for planting. Transplanted (as opposed to direct-seeded) crops have an advantage in that they will be ahead of any weeds that germinate after planting and, if growing vigorously, will quickly shade out the weeds. Direct seeding tends to disturb the soil surface, encouraging weed germination. Irrigation can be crucial, especially for small-seeded species because they are not sown as deeply as large-seeded species. The soil surface must remain moist for longer to ensure good germination. Shallow-planted seeds are also more likely to be eaten by ants and birds.

Another consideration is seedling vigour. Some species—for example, onions—have extremely slow early growth, particularly in cold and wet conditions. Weeds, on the other hand, are better adapted to these conditions and will quickly smother struggling vegetable seedlings.

In general, small-seeded species are best transplanted—unless, like carrots, they do not like root disturbance—while larger seeded species such as pumpkin can be direct seeded.

When seeding or transplanting, it is important that rows are uniform and straight, so that inter-row operations such as weeding can be carried out accurately.

Plant spacing

The sowing rate between and within rows is generally higher in organic systems compared with conventional systems. Higher sowing rates mean that gaps between the crop plants will be quickly filled, which discourages weed competition. Care is needed, however, to avoid compromising crop quality. A higher sowing rate also increases inter-crop competition and can result in a reduced overall yield or smaller sizes for produce; for example, onion bulb size and cauliflower head size decrease with increased sowing density, although this can also be used to advantage if the aim is to produce 'mini-vegetables'.

4.5.4 Post-planting operations

Post-planting cultural operations consist of weed and pest management and, if required, application of organic fertiliser. Accuracy when operating equipment and precision timing of operations are essential. Specially designed inter-row cultivators can remove young weeds from around the crop. One such implement is the WeedFix®, which consists of a series of rotating tines mounted either side of crop guards. The tines 'stir' the soil surface, dislodging weeds, while the guards prevent damage to the crop. The tines can be operated in two directions—either throwing soil towards the crop, thus smothering weeds in close proximity to the crop, or throwing soil away from the crop, removing the weeds.

Other types of equipment are also available for post-planting cultural operations, among them flame or hot-air weeders, brush weeders, rotating cultivators, and various toolbar attachments such as bean knives and Alabama sweeps. Highly recommended reading is *Steel in the Field: a farmer's guide to weed management tools* (Bowman 1997), which documents farmers' experiences in this regard. See: < http://www.sare.org/publications/steel/steel.pdf>

4.6 Irrigation

Organic standards require that irrigation monitoring and scheduling techniques be used and that irrigation practices minimise disturbances to the environment and natural ecosystems.

The best possible yields are obtained by maintaining uniform

soil moisture in the root zone during the growing season. This requires a thorough knowledge of the crop's water requirements and the soil's water-holding capacity. Applying only the amount of water required by the crop leads to savings on pumping, fertigation (irrigation incorporating nutrients) and water costs and limits run-off problems. Information about good irrigation management practice is available on the NSW Department of Primary Industries website <http://www.agric.nsw.gov.au/reader/8054>. Also available from the department are publications providing guidelines for irrigation of processing tomatoes, onions and carrots, and melons.

Drip irrigation is the most efficient form of irrigation. It provides water directly to the plant, rather than wetting the entire soil surface, which can encourage additional weed growth. It has the further advantage that nutrients can be supplied by fertigation to the crop during the growing season. Cultural operations can, however, be made more difficult if the drip lines are laid on the bed's surface.

Drip lines can be installed beneath the surface to facilitate cultural operations, although roots can grow into the lines and cause blockages. Most subsurface drip is impregnated with a herbicide to prevent root intrusion, so organic producers need to inform manufacturers that they require herbicide-free drip line. Seasonal flushing of lines—with an organically approved substance—should be carried out to ensure that the lines are kept free of blockages.

Furrow irrigation is another form of irrigation commonly used in vegetable production, but it is becoming less popular because of increased water costs and environmental awareness. Furrow irrigation of row crops usually results in considerable tail drainage, and this should be collected into a drainage recycling system. The recycling saves water, reduces nutrient loading in off-farm waterways, and provides an opportunity to increase biodiversity through wetland construction. The NSW Department of Primary Industries publication *Managing Wetlands on Farms* (1995) is a useful guide to planning and establishing on-farm wetlands. The NSW DPI Agnote: *Managing waste water from intensive horticulture: a wetland system,* can be viewed at: <http://www.agric.nsw.gov.au/reader/horticulture-wastewater/dpi381.pdf?MIvalObj=10076&doctype=document&MItypeObj=application/pdf&name=/dpi381.pdf>



The WeedFix® cultivator has been used successfully to control a range of weed species in row crops at the NSW Department of Primary Industries organic demonstration site, Yanco. Photo: NSW Department of Primary Industries.

Irrigation management is also a valuable tool for controlling weeds. Strategic scheduling of irrigation can be used to germinate weeds so that control action can be taken before the main crop is planted.

Producers should consider undertaking an irrigation management course such as Water Wise on the Farm. These are offered by state agriculture departments and in some cases can be a prerequisite to obtaining an irrigation licence.

4.7 Weeds

The use of synthetic herbicides is prohibited under organic standards, and many organic producers say that effective weed management is one of the greatest impediments to conversion and successful organic vegetable production.

4.7.1 Planning a weed management program

The following principles should be considered when planning a weed management program:

- Learn to identify weeds. Learn about weed lifecycles and growth habits—including the time of emergence, growth rates, the method of dispersion, and the time of seed set—and why the weeds are filling that ecological niche.
- Maintain a longer term outlook, rather than focusing only on the current or coming season. It is necessary to determine how weeds can be managed throughout the rotation. Seed bank reduction can take a number of years.
- Take an integrated approach to weed management. Avoid relying on a limited number of methods. Be innovative with equipment, tillage and rotations.

- Planning should aim to prevent weed outbreaks. Once there, weed problems are much harder to manage.
- Observe and record changes to weed populations in each field.
- Introduce changes to the lowest risk crops in the rotation.
- Identify the soil characteristics or management practices that favour specific weeds. The presence of a particular weed species might be an indication of a soil fertility or soil structural problem. A slight change in pH or improvements to irrigation management or drainage can change the conditions that were prompting growth and the spread of the weed.
- Build weed management strategies into whole-farm planning. For example, design a fence layout and paddock size that allow for strategic grazing (for example, with goats), grow less competitive crops in paddocks where weeds are not a problem, leave uncultivated areas to host potential biological control agents (for example, Patterson's curse weevil), and choose crops that are able to compete effectively with weeds.

It is important to also remember that weeds can be beneficial. Among the possible benefits to the farming system are erosion control, habitats for insects, capturing soil nutrients and moisture at depth, and food or medicinal value for livestock (provided of course they are not toxic).

4.7.2 Reducing the bank of weed seed

Preventing weeds going to seed can greatly reduce weed pressure. Most soils contain a significant weed seed population, and each time soil is disturbed some of the seeds will germinate. It is possible, however, to gradually reduce this population by preventing weeds going to seed during the season and following up with off-season control measures.

Planting short-season crops such as lettuce provides more opportunities for weed suppression; competitive cover crops can smother weeds. Cultivation plus grazing and mowing weeds can prevent weed seed set. If the weeds do manage to set seed, baling the weeds into hay and removing them from the paddock before seed dispersal is an option. The hay could then be used in compost production. Proper composting makes seeds non-viable.

4.7.3 Management practices

Surveys of organic growers reveal that the most frequently used weed management tactics are manual and mechanical tillage, rotations including vigorous cover crops, slashing, and numerous cultural practices (Kristiansen et al. 2001). An integrated approach to weed management relies on planning long-term remediation strategies—such as soil improvements or the use of biological controls—backed up by short-term management practices.

Hand weeding

Perhaps the single most valuable tool in organic weed management is hand weeding, which can involve chipping or digging using a hand-held implement or pulling out weeds by hand. One weed allowed to seed could become an outbreak in a few seasons. Successful organic farmers never walk past a 'potential' weed problem. Hand weeding is often useful in inaccessible areas or for a final clean-up after relying on other methods.

Mulching

Organic farmers use mulches to help reduce weed competition, conserve soil moisture, lower soil temperatures, and prevent erosion. Among the organic materials used are hay, paper and cardboard, compost and sawdust. Organic standards prohibit the use of solid non-woven plastic or synthetic material sheets as mulches. Sometimes, woven plastic or synthetic materials are approved, provided they are completely removed from the paddock following harvest. To be effective, organic mulches should be applied and regularly maintained to a depth of 100 millimetres.

A green-manuring technique that uses the residues of crops (such as vetch) grown in the preceding season can also provide a mulch against weeds. The main crop is then planted into the residual surface mulch of the cover crop. The cover crop is also referred to as 'living mulch' or 'smother crop', and the technique relies on the senescence of growth in that crop, which is then broken down to form a surface mulch. Cowpeas and cold-sensitive clovers have been used with success.

Tillage

For tillage, *Steel in the Field: a farmer's guide to weed management tools* (Bowman 1997) is essential reading.

Primary cultivation practices such as deep ripping can improve drainage and alter the weed species composition in a field. Primary cultivations, in combination with other control measures such as green manuring, should aim to reduce the weed burden before planting the crop. The final primary cultivation before planting should be carried out after optimum weed germination.

Secondary cultivations—those performed during seed-bed preparation or after planting—should be shallow and should aim to remove weed seedlings while minimising soil inversion or soil

mixing, to prevent a 'new' weed seed bank from establishing at the soil surface.

Other techniques such as flaming avoid soil disturbance and, if properly timed, can be an effective alternative to cultivation. Such techniques are based on the idea that weed seeds require exposure to light to germinate. The seedbed is formed about two to three weeks before the crop is planted. After seven to ten days of good growing conditions (moist soil and warm temperatures), there is a flush of weeds, which can be killed with flame weeders or cultivation. Assuming all the weeds are killed and the soil on the bed is undisturbed (except for the minimal soil disturbance from seeding or transplanting the crop), fewer weeds should germinate during the season to compete with the crop. There is some evidence that, because of this need for exposure to light, night cultivation can also drastically reduce the germination of certain weed seeds.

In row-cropping situations, good weed control is facilitated by creating and maintaining evenly spaced, straight hills or beds. Mechanical weed control between crop rows, using implements such as rotary tillers (for example, the WeedFix®), should be carried out when the weeds are small and the crop is at the two- to three-leaf stage and, if necessary, again at the five-leaf stage or while it is still feasible without damaging the crop. Once the crop canopy has closed, competition from weeds should be minimal.

The most difficult place to manage weeds is within the crop row, and hand weeding is probably the most common method here. Having crop guards around tillage implements will allow weeding to be done as close as possible without damaging the crop.

To ensure a good weed kill, cultivations should be avoided if rain is imminent and should be timed for the earlier part of the day during hot, dry and windy conditions. Avoid cultivating wet soil: it will become compacted and drainage will be impeded.

The choice of tillage equipment depends on the job at hand, budget, and the equipment's commercial availability. Many vegetable growers use rolling cultivators because these allow shallow cultivation and can be adjusted for different row spacings and crop configurations. Mouldboard ploughing during primary tillage operations is the most effective way of reducing weed populations because it buries seeds deeply enough to reduce germination and establishment. Mouldboard ploughing is, however, considered more destructive of soil structure than chisel ploughing.

Any form of prolonged tillage will affect the soil structure and increase compaction, as well as predisposing the paddock to erosion and fertility loss.

In summary, the following practices for mechanical cultivation should be adopted:

- Adjust equipment accurately for each cultivation.
- Establish straight rows and beds far enough apart to avoid injuring crop plants during between-row cultivations.
- Withhold irrigation after cultivation or avoid cultivating weeds if rain is imminent, to prevent the weeds from re-establishing.
- Establish 'traffic' rows to avoid compaction throughout the field.
- Hand-hoeing might also be practical on some crops. To avoid adverse effects from root damage to the crop, hoeing should be done before the crop and weeds are large.
- Narrow the row spacings or increase the planting density. Narrow row spacings will produce faster canopy cover, shading out weeds.

Water management

Effective water management is a central ingredient of weed management in organic production.

Pre-planting irrigation or rainfall stimulates weed emergence, after which weeds should be killed by shallow cultivation or by flaming. Planting of the main crop should occur shortly afterwards to avoid further weed germination as a result of rainfall.

Burying drip irrigation lines below the bed surface provides water to the crop but restricts the water's availability to weeds closer to the soil surface, particularly if rainfall does not occur. Post-planting operations are also be greatly facilitated if the drip line is buried.

Crop physiology

Vigorous crops often out-compete weeds. Fast-growing crops can quickly cover beds and fill gaps in the crop stand that weeds might otherwise occupy. Species with large leaves can shade out competing weeds.

Biological weed control

Various biological agents are available to facilitate weed management. Among them are insects (for example, crown root weevil for control of Patterson's curse), fungi and bacteria (for example, rusts formulated into biological herbicides known as myco-herbicides) and plant derivatives (for example, corn gluten meal, some vegetable oils and plant root exudates such as those from oilseed rape). Some of these agents have been formulated into commercial products known as bio-

herbicides. The certifier's approval should be obtained before any treatment is used.

Some biological agents are effective over a longer period and rely on establishing and maintaining a colony of organisms. The organisms' persistence—and hence long-term weed control—is dependent on the presence of a sustainable food source as well as suitable habitat, so it is desirable to set aside an area where there is a low level of the host weed or there is an alternative food source. These areas are usually uncultivated borders—for example, in windbreaks—adjacent to cropping areas.

Researchers often look for unsprayed or uncultivated sites in which to release biologicals, so an opportunity may arise to collaborate in trial work to evaluate the new control agents.

Of course, genetically modified organisms are not permitted as biological controls in organic systems.

Flame weeding

Flame weeding can be used to control weeds before and after germination of the crop. Effective pre-emergent flaming calls for good timing. The operation must be done after a flush of young weeds appears but ahead of significant crop emergence. The most effective time to kill weeds is before the three- to four-leaf stage. 'Indicator' seeds can be sown with the crop: they can be timed to emerge just before the crop in order to determine when it is safe to flame.

Post-emergent flaming is accomplished either by cross-flaming or by parallel-flaming. In cross-flaming, burners are set on either side of the crop row, in a staggered pattern, the burners being placed perpendicular to the row, so that the combined flames cover the entire drill area. In parallel-flaming, the burners are again set on either side of the row, but the flames are placed parallel to the row.

Ideally, beds should be smooth, with minimal clods: protruding clods or uneven terrain can shield small weeds or deflect the flame into the plant canopy.

For energy-efficient flaming it is desirable to travel as fast as possible, using the lowest gas pressure and thus the least fuel. Although there will be little immediate effect visible, the weeds will droop and wilt within a few hours. A quick way of testing whether the flaming has been effective is to firmly squeeze a plant leaf between thumb and forefinger, then let go. If there is a fingerprint where the leaf was squeezed, the heat has burst the cell walls and the leaf will wither.

For flaming to be successful, operations need to be carefully timed. When weed pressure and planting schedules allow, delay the final flaming until just before planting. This gives the crop the least weed competition during its most vulnerable stage. Flaming is best done in the heat of the day, when it is hot and dry with little or no wind.

Flaming has differing impacts on pests and their predators, so it is important to carefully monitor populations to see how they are being affected. For example, US researchers have found that ladybird beetles survive higher temperatures better than do tarnished plant bugs, a serious cotton pest. The ladybird preys on the pests in both their larval and adult stages; further, the tarnished plant bug appears at about the same time that cotton plants can first tolerate flaming.

Crops differ in their susceptibility to damage from flaming. Onions are flamed at around two weeks after the transplants are established. Corn, however, can be flamed at any time, although many flame users do not flame from the 12–25 centimetre growth stage, to avoid stressing the plants while their root system is developing.

Green beans, on the other hand, cannot handle exposure to the flame, so flaming is used only before emergence, to deal with the initial flush of weeds. With sensitive plants such as beans, plant parts can be protected from the flame by a wall of mist. Spraying a thin layer of water over the plants with flat-fan nozzles helps to protect them.



Flame weeding in corn. Source: Nova Scotia Agricultural College, <www.nsac.ns.ca/eng/staff/ nri/flameweeding.htm>.

For some crops that send up early leaves before their growing point emerges, early post-emergence flaming can be used. Even if the young leaves are singed, the crops will recover provided the growing point survives. Once the growing point emerges, allow substantial growth before flaming the stalks.

Two types of flaming equipment are generally available. One is a hand-held propane flamer connected to a backpack-supported fuel tank. This manual method allows for greater selectivity and accuracy in applying the flame and is generally used in inaccessible areas or for small weed outbreaks. The other type of equipment involves propane burners that can be either individually mounted or attached to a two-row, rear-mounted tractor-drawn cultivator. These can be four- or six-row flamers, depending on the size of the operation. This method is generally used for large areas and, if the burners are attached to a cultivator, allows flame weeding and mechanical cultivation to be done in one pass. The burners need to be adjusted in order to work efficiently with a cultivator because the soil the shovels throw can interfere with the flame hitting the target weeds.

For flaming between rows of emerged crops, accuracy and the safe use of equipment are essential. The following are considerations in this regard:

- The burners' height and angle (vertical and horizontal) should be carefully adjusted, and fuel pressure, tractor speed and regulator setting checked frequently.
- Young crops should be carefully checked for flame damage to stems, buds or leaves.
- Flaming should be restricted to calm weather, and attention should be paid to the speed and direction of any air movement.
- The burners should be adjusted to a pilot setting when turning at the end of rows.
- Burner nozzles should be cleaned out each year to remove the carbon and rust that can flake off the inside of the steel pipe that leads to the burners. A bluish centre flame should be visible during peak operation.
- Operators need to be familiar with, and practise, the safety rules for proper inspection, filling and use of propane tanks and equipment.
- It is advisable to gain approval from local fire authorities before flaming. Never flame during a total fire ban.

Sanitation

Good sanitation can help to prevent new infestations and the spread of weeds. It involves the use of well-graded seed, removal of crop refuse, thoroughly composting manures and green waste, as well as cleaning down machinery between operations and before moving from one field to another. Livestock can act as weed carriers if they have been grazing on weed seed in infested pastures or have been hand fed on grain. Mulch applied to crops should be free of weed seeds. As noted, proper composting of crop refuse destroys weed seeds.

Solarisation

Solarisation, a technique used to kill weeds (as well as some pathogens and nematodes), involves placing clear plastic film over moist soil. The plastic is applied during the hottest part of the year for four to six weeks. The soil temperature should reach 60°C at a depth of 5.08 centimetres and 39°C at a depth of 45.7 centimetres. The main difficulty with soil solarisation is finding a time between crops when temperatures under the plastic are high enough for long enough to be effective. Once solarisation is completed, the plastic film used can be recycled for future use or disposed of in an environmentally acceptable manner.

Weeds vary in their susceptibility to solarisation. Winter annual grasses, barnyard grass, black nightshade, chickweed, field bindweed seedlings, hairy nightshade, prickly lettuce, red-root pigweed, and shepherd's purse have been reported to be controlled by solarisation. In contrast, Johnson grass, nut grass, purslane and established field bindweed are only slightly affected.

Experience in the United States suggests the following general guidelines when applying soil solarisation:

- Solarisation is most likely to be effective during long days of high temperatures and no wind.
- Clear 1-millimetre-thick plastic should be adequate and is not expensive, but in windy areas thicker (1.5 to 2 millimetres) plastic might be necessary to prevent tearing. If the plastic is to be used as a mulch with the following crop, it must have UV inhibitors. Otherwise, sunlight and high temperatures will start to break the plastic down after four to six weeks.
- The soil–plastic contact should be as tight as possible in order to raise the soil temperature as much as possible and as deep as possible. Thus, the area to be solarised must be levelled and free of weeds and large clods of soil that could lift the plastic off the ground.
- Moist heat is more damaging to pathogens than dry heat. Irrigating with drip lines placed under the plastic is usually the most effective method.
- Plastic must completely cover the soil surface. There is an edge effect of up to 60 centimetres in which temperatures will be cooler and solarisation less

effective, so solarisation in narrow strips is not likely to be effective.

- The plastic must be left in situ for four to six weeks.
- Deep cultivation should be avoided before planting the next crop, to avoid bringing non-solarised weed seeds to the surface.

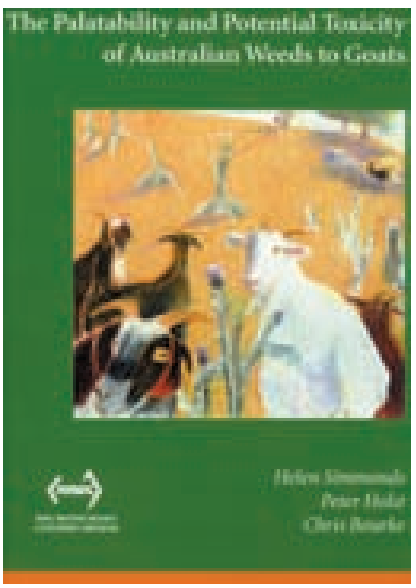
Organic sprays

A number of organic sprays are approved for weed control under the National Standard for Organic and Biodynamic Produce. Among them are essential oil sprays, homeopathic products and biodynamic peppering. The efficacy of these substances is yet to be scientifically evaluated. A pine oil derivative is approved for use by some certifiers; some preliminary trials with this product have shown minimal efficacy.

Scientists from the US Department of Agriculture's Agricultural Research Service in Beltsville, Maryland, have demonstrated effective control of a common range of broadleaf weeds by spraying vinegar on plants. Five and 10 per cent concentrations killed the weeds during their first two weeks after emergence; at higher concentrations, the vinegar had an 85 to 100 per cent kill rate at all growth stages. The vinegar used was made from fruit or grains, to conform to organic farming standards.

Grazing animals and birds

Goats, pigs, sheep, and other animals will eat weeds but will also root out or graze any crop plants present in the field. Pigs are sometimes useful to root out tubers of nut grass and Johnson grass before a crop is planted. Sheep can be used to 'crash' graze paddocks to prevent seed set. Goats and some breeds of sheep (such as dorpers) are foragers and will often eat plants that are less palatable to other species. Grazing by goats is a very useful weed control strategy, but owners need to be aware of potential toxicity risks. The RIRDC publication *The Palatability and Potential Toxicity of Australian Weeds to Goats* (Simmonds et al. 2000) provides suggestions for control strategies and outlines the health and production problems that may result.



Geese are one of the few animals that can be used once the vegetable crop emerges. In 1960, 175 000 geese were used as weeders in the United States, mainly to remove grasses from broadleaf crops such as cotton. Geese eat Johnson grass, sedge and nut grass, clover, chickweed and many other weeds. White Chinese weeder geese at least six weeks old are the best feeders. Because of their light body weight, they do little damage to crops if they step on them. If a larger goose for processing is required, Toulouse or Embden would be suitable. Some consider African weeder geese to be even better than the Chinese breed.

The geese should be grazed at rates of seven to twelve geese per hectare, depending on the weed population. In some crops and climates where weed growth is extreme in the early spring, more geese may be needed. It is crucial to start with enough geese and then remove (or sell) them as weed growth permits (usually when 75 to 90 per cent of their preferred food is gone); otherwise, they might begin eating the crop.

Geese generally prefer the tender young shoots of grasses and sedges over broadleaf vegetables. They need a constant supply of fresh water, so placing their water near weedier areas can help with weed management. When an area is weeded the water containers can then be moved into an area that is weedier. When checking on the geese, it is a good idea to carry a hoe to remove the weeds the geese find unpalatable.

Geese must have access to shade and be fenced in and protected from predators. Movable shelters



Chinese weeder geese (background) and ducks help with weed and pest management in organic vegetable production systems. Source: <http://www.fbts.com/animals.htm>.

can be useful. Strip-grazing geese concentrates their efforts on areas most in need of attention. This can be done using electric net fencing. Electric netting is available from Gundaroo Tiller in New South Wales (see Appendix A).

Geese can be 'conditioned' to eat weeds they normally do not eat if the undesirable weeds are fed to them when they are goslings. Geese and sheep can be grazed together. The sheep eat many of the broadleaf weeds the geese find unpalatable.

Since geese are vegetarian, a small number of ducks (such as Khaki Campbells) can be kept with the geese to help control insects, slugs and snails.

Information on raising geese is available on the NSW Department of Primary Industries website < http://www.dpi.nsw.gov.au/agriculture/livestock/poultry/species/geese-raising >.

4.7.4 Managing problematic weeds

Weeds that organic growers commonly report as problematic—examples are couch, dock, kikuyu and sorrel—tend to have underground parts that are less vulnerable to the usual forms of non-chemical weed control such as tillage and mulch or are heavily seeding annuals (Kristiansen et al. 2001). Some annual weeds have very long-lived seeds and can survive for more than 40 years before germinating.

The primary approach to controlling perennials with cultivation is to separate the above-ground and underground parts and then exhaust the food reserves in the underground part. Tap-rooted and shallow-creeping perennials are generally easier to control; the deep-creeping and tuber, corm and bulb types are often the most problematic. Difficult-to-manage annuals are controlled by preventing the conditions that encourage seed germination and by stopping further seed set. Merfield (2000) provides some useful management strategies for weeds of this kind.

Noxious weeds

Farming organically does not exclude anyone from adhering to laws imposed by the Commonwealth or the states and territories. Under the New South Wales *Noxious Weeds Act 1993*, for example, producers are required to control certain weeds. The Act does not specify chemical control, but it does specify that the noxious weed be either fully and continuously suppressed and destroyed (for W1 and W2 category weeds) or be prevented from spreading and its numbers and distribution reduced (W3 category weeds). For a W4 noxious weed, the action specified in the declaration must be taken. The Act can be viewed online < http://www.legislation.nsw.gov.au/viewtop/inforce/act+11+1993+FIRST+0+N > and details of weeds declared in New South Wales can be viewed online at < http://www.dpi.nsw.gov.au/agriculture/noxweed >.

4.8 Managing pests

Organic standards prohibit the use of synthetic insecticides and discourage a pest management strategy that substitutes reliance on synthetic insecticides with allowable organic insecticides. Under the standards a more holistic approach needs to be adopted, which essentially comes down to an 'integrated' pest management strategy. Integrated pest management uses all suitable (and allowable) techniques to manage pest populations below levels that cause economic damage. It is now best practice in conventional agriculture. An organic grower has fewer tools and techniques available, but the approach is the same. It is possible to produce high-quality, relatively blemish free food, but to do so without resorting to agricultural chemicals calls for a higher level of management and a greater understanding of the whole system.

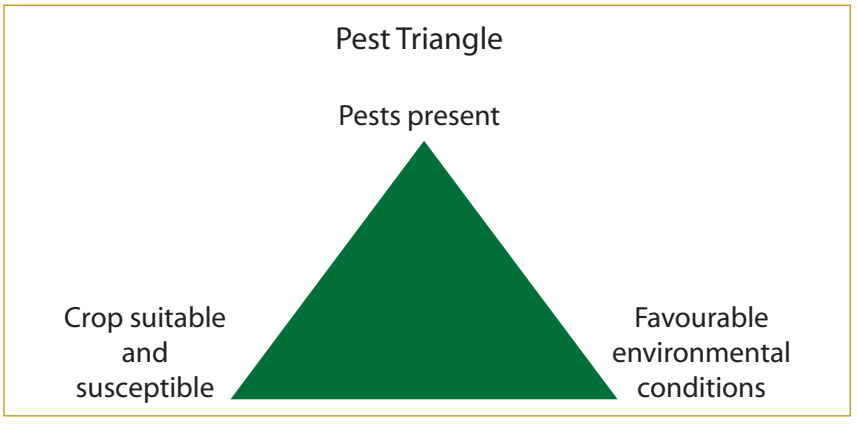
4.8.1 Planning an organic pest management program

Instead of using synthetic pesticides, organic farmers adopt cultural practices that encourage healthy plant growth and other practices that encourage predators of pests.

Three conditions must pertain if a pest problem is to develop:

- The pest must be present.
- The crop must be a suitable and susceptible host.
- The environmental conditions must be favourable.

These conditions can be thought of as the 'pest triangle'.



The first step in an integrated pest management system lies in knowing what pests are likely to, or might possibly, attack the crop, the pests' life cycles, what conditions favour their survival, and what conditions or natural enemies might control the populations. The second step is to pre-plan the cropping system to minimise the potential for pests to become a problem. The third step is to monitor the conditions that might favour a pest outbreak. If all the conditions of the pest triangle are favourable to a pest outbreak, the fourth step is to intervene, to modify those conditions in order to reduce the risk or severity of damage. Figure 4.1 illustrates this.

Step 1: Knowledge

Key pests

Less than 1 per cent of all insects are 'pests'. But agricultural production creates conditions that favour the build-up of a small number of insects to pest levels. 'Key' pests tend to be insects that are likely to cause serious damage if left unmanaged. They can be regular pests, as *Heliothis* is on tomatoes and many agricultural crops, or they can be irregular but potentially devastating, such as russet mite on tomatoes or pumpkin beetle on cucurbits. Lists of likely or possible pests and a number of crop guides for most agricultural crops are readily available from state departments of agriculture. In many cases the types of pests—for example, aphids, leafhoppers and *Heliothis* caterpillars—attacking a particular crop are similar species and, in some cases, the same species across different regions and countries, which is helpful when seeking information about potential management strategies.

Pest biology and life cycles

Knowledge of a pest's biology and life cycle is essential for finding out where it is most vulnerable and how it is most likely to be managed. The more one knows about them the more likely it is one will find ways to thwart their successful development.

The native *Heliothis (Helicoverpa armigera)* is a good example. The moths emerge from over-wintering in late spring; they are active from early evening and need to mate before the females can deposit single eggs. Male moths find females by tracking (smelling) a sex pheromone the females emit.



Heliothis (Helicoverpa armigera)

The females deposit up to 1000 eggs in their lifetime. The moths live primarily on the fat stored since they were caterpillars and only need to drink water or, if possible, nectar. Depending on temperatures, the eggs can take from four to 30 days to hatch. The warmer the temperature, the sooner the eggs hatch; for example, over a fairly typical temperature cycle in a temperate summer, when daytime temperatures are in the mid-30s and night temperatures drop down below 20°C, a *Heliothis* egg can take seven days to hatch. After the egg has hatched the newly emerged larvae immediately start feeding, initially just grazing the leaf or fruit surface. *Heliothis* caterpillars like to be in protected situations, so they will also seek shelter inside developing fruit or in the heart of leafy plants such as lettuce. The larvae or caterpillars are feeding machines, and as they grow too big for their skins they moult into the

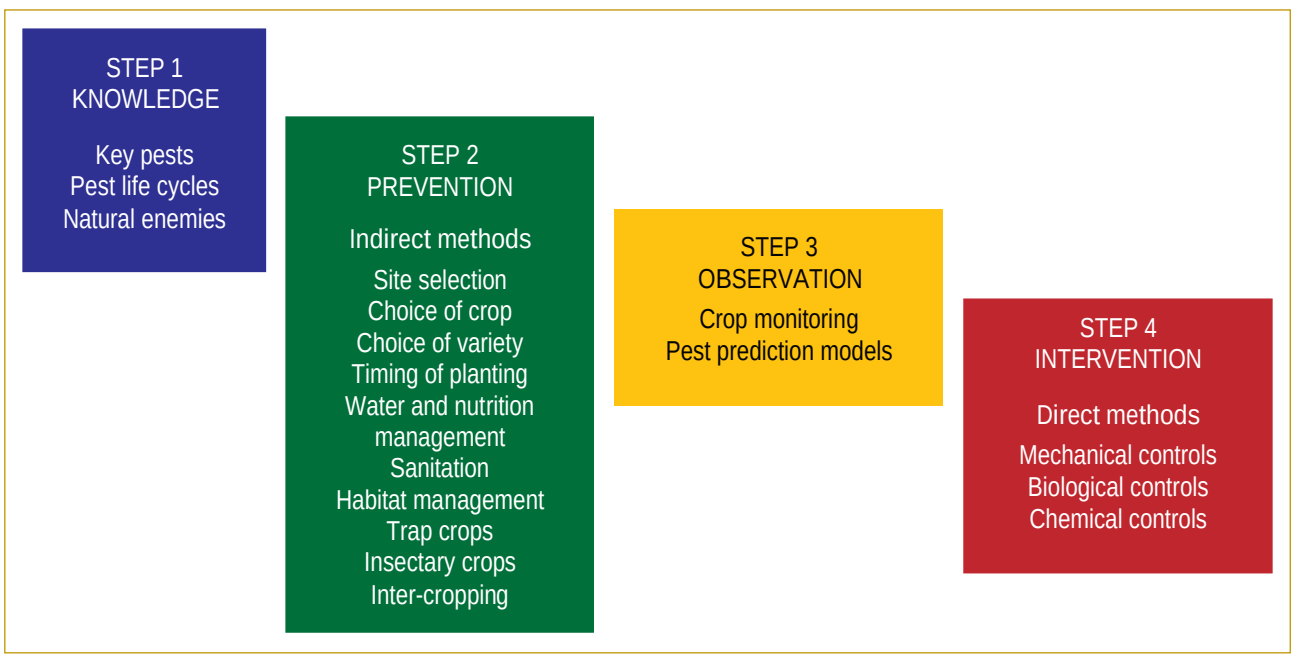


Figure 4.1 An integrated pest management system. Source: Adapted by S McDougall (2001).



Davidson and Davidson (1992) give the example of 1000 ibis consuming nearly a quarter of a million pests during a day.

next instar, or larval, stage. *Heliothis* have six instars. At the completion of the sixth instar, the caterpillar burrows into the soil to pupate. Most pupae are found in the top 10 centimetres of soil. If pupation takes place during summer, the moth will develop, then crawl to the surface along the tunnel the caterpillar dug and, once emerged, repeat the cycle. In much of temperate Australia *Heliothis* have three to four generations a year. As autumn progresses an increasing proportion of the pupae will enter a winter diapause and will not complete development until the following spring.

There are several things to note from this life cycle:

- The moths are not active in the day or are not readily observed, but male moths can be caught in pheromone traps.
- Eggs are exposed from four to 30 days, depending on temperatures.
- Newly emerged larvae often feed in exposed situations, but later instars tend to be protected.
- The larvae cause the damage to the crop, and the later instars feed the most.
- Moths cannot burrow, so any damage to the exit tunnel will prevent moths emerging.

The resulting management options are as follows:

- monitoring moth flights with pheromones
- monitoring egg numbers and, if intervention is required, targeting treatment to egg hatch
- if larvae are missed, the next opportunity for management is to cultivate the soil after pupation to destroy the exit tunnels—known as 'pupae busting'.

Natural enemies

In natural environments most organisms' populations are kept in check by a range of 'natural enemies', among them bacterial, viral and microsporidium diseases, nematode infections, parasites or parasitoids, and predators. These natural enemies are called 'beneficials'. Most insect pests have a range of specific and generalist natural enemies that either kill them or limit their ability to cause damage or reproduce. In most agricultural systems—and particularly those that use few, if any, insecticides—there are a range of generalist predators. Davidson and Davidson (1992) give the example of 1000 ibis consuming nearly one-quarter of a million pests during a day.

Populations of specific natural enemies can build up in the presence of the pest. If natural enemies are to thrive they need the 'beneficial' equivalent of the 'pest triangle':

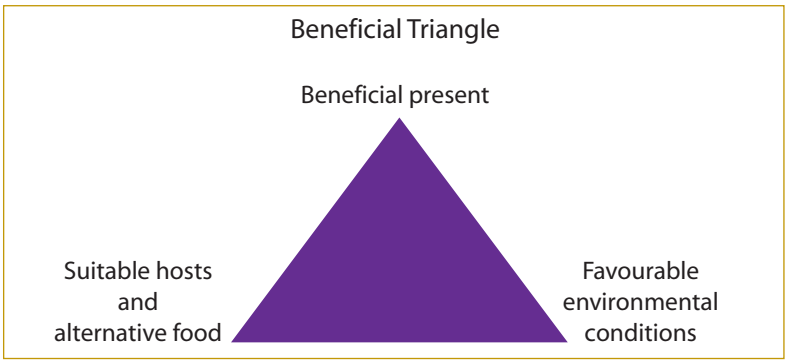
- The beneficial must be present.
- There must be suitable hosts and, in some cases, a nectar or pollen source.

The environmental conditions must be favourable.

Shelter, breeding grounds and year-round food sources encourage predators. Nectar-producing species incorporated in pastures and windbreaks attract parasitic wasps, which parasitise scarab species in pastures. On-farm wetlands encourage predatory waders and, if correctly located and properly designed, provide a filter for nutrients in drainage before it leaves the farm. Ideally, there are suitable non-pest hosts for the beneficial populations to increase, so that if a pest arrives it finds itself in a hostile environment.

Step 2: Prevention

Within a pest management system, it is wise to prevent or limit the likelihood of pest populations causing serious damage. A variety of cultural control methods can be used to reduce the likelihood of pest outbreaks.



Site selection

Some sites will be more prone to pests than others. For example, growing organic tomatoes next to large plantings of sweet corn or other *Heliothis* host crops will increase problems with *Heliothis*. Choose sites that are isolated from sources of pests.

Choice of crop

Choose a crop that is optimal for the location: a strong, vigorous plant is less susceptible to attack. When growing organically, it is often better not to grow crops that are already grown extensively in the area, unless there are natural barriers that reduce the flow of pests onto the organic land.

Cultivar selection

Some cultivars are resistant to, repel or are less palatable to pests than other cultivars. In sweet corn, for example, the H5 variety has a tighter 'throat' to the cob, reducing *Heliothis* caterpillars' access.

Crop rotations

To reduce soil-borne pests and diseases, rotate host with non-host crops. Rotations can also break insect pests' life cycles and help control weeds.

Material from off-site

If using transplants or bringing any materials to the site, assess the risk of bringing pests with them. Insects, and particularly diseases, can easily come from off-site contamination.

Timing of planting

If possible, choose planting times when pest pressure is likely to be lowest. Early planted crops of processing tomatoes experience less *Heliothis* pressure than later planted crops.

Crop health

Plants growing with optimum water and nutrition tend to be less susceptible to pest attack and might better compensate for damage. Over- or under-provision of water or nutrients will stress the plant and increase its vulnerability.

Sanitation

Many key pests have many host plants. If those host plants are weeds or old harvested but uncultivated crops, they can contribute to supporting the pest population on the property. Controlling weeds—particularly flowering weeds—is crucial for the successful management of, for example, western flower thrips. Mites are often spread through properties or from crop to crop by machinery or on the clothes of people walking through the paddocks.

Natural habitats

Natural habitats provide a source of beneficials to colonise the farming system.

Trap crops

In some instances other crops might be the preferred habitat for a particular pest, and if some of the preferred crop is grown it might draw the pest away from the main crop. For example, pigeon peas have been used successfully as a trap crop for *Heliothis* in soybean production. In some cases a particular crop stage is preferred by the pests, so a small sacrificial planting can be used as a trap crop.

Insectary crops

Many beneficial insects require nectar or pollen as food sources, and a nearby flowering crop can act as an insectary crop and help increase the number of beneficials working the main crop. Other insectary crops can be crops that host a related non-pest species—for example, a species of aphid that can then support the establishment of aphid parasitoids and predators that might move into the main crop if aphids become established there.

Inter-cropping

Alternating rows of different crops has been used as a means of reducing pest pressure. Of itself, inter-cropping does not reduce pest pressure, but some combinations of crops work well together and result in less pest pressure. Inter-cropping is not widely used in highly mechanised or extensive agricultural systems: it is most typically used in labour intensive systems such as market or home gardens.

Step 3: Observation

Once the basic system for reducing pest incursions and build-ups and maximising the effects of beneficials is in effect, the next step is monitoring. Agricultural environments are complex systems, and changes in weather or the arrival of a key pest can rapidly change a pest situation. Regular observation of the factors in the pest and beneficial triangles can warn of a potential problem while there is still time to respond.

Crop monitoring

Systematically checking crops for the key pest stages (for example, eggs for *Heliothis*) and using available traps (for example, pheromone traps or sticky traps) to help monitoring are fundamental to developing an ability to respond to an emerging problem. Weekly checks are recommended for most crops, with more frequent checking during periods of high vulnerability or high pressure. In some areas commercial scouts monitor crops for a fee.

Pest identification

Whilst in the process of learning about the pests and beneficials that visit crops, it is important to have insects or diseased plants identified by an expert. Most state agricultural departments offer diagnostic services. Some insects, such as thrips, are hard to identify in the field and, although many different

species of thrips often visit a single crop, the presence of western flower thrips can radically alter a pest management strategy. Thrips are often most easily monitored by using sticky traps, which can be sent to the NSW Department of Primary Industries Insect Diagnostic Laboratory (take them to the nearest department office or send them to Orange Agricultural Institute, Forest Road, Orange NSW 2800), the Beneficial Bug Company, or another commercial group to check for the presence of western flower thrips.

Pest prediction models

Insects and diseases tend to respond predictably to temperature and/or moisture levels, so models can be developed. In some cases the models can be developed into prediction models, and for some cropping systems, such as cotton, there is crop management software that can help predict pest problems with the input of a range of data. At present there are no such models for vegetable crops in Australia. A *Heliothis* development model can be downloaded from the web <http://www.uq.edu.au/~uqwroche/gentime/> and, with the input of temperature information or using historical records for the area, it can predict the period of each life stage.

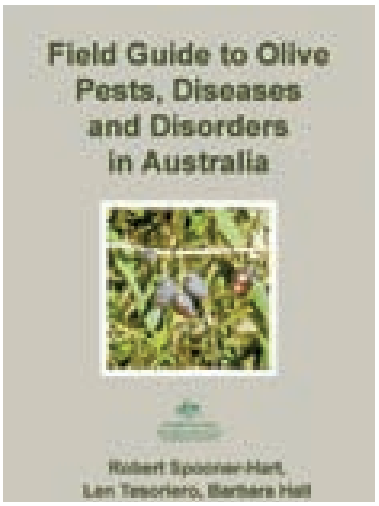
Step 4: Intervention

If observations of the crop or cropping situation suggest a need for action to reduce a likely or current pest build-up, the available tools fall into three categories—mechanical, biological and chemical controls.

Mechanical control

Mechanical controls are methods that can physically remove pests or physically prevent them moving into the crop.

- *Light or bait traps*. Moths and some beetles are attracted to black light and so can be caught in a 'light trap'. These traps are not very selective, which means that a large number of non-pest, and possibly beneficial, insects might also be trapped. In Western Australia some lettuce growers use large light traps to help manage Heliothis. Some insects such as fruit fly are attracted to fermenting yeast or other 'baits' and can be trapped this way. Pest-specific pheromones can greatly increase a trap's attractiveness to the target pest.
- *Bug vacs or suction devices*. In the United States large vacuum cleaner–like machines are used to suck up all the bugs in a crop. Strawberry growers have been the most successful users of this technique. It is not very specific, however, and beneficials are as likely, if not more likely, to be sucked up. In some cases a modified leaf-blower is used to collect beneficials from insectary crops or areas where their numbers are plentiful; they are then released in a crop where their numbers need to be increased.
- *Covers and barriers*. For high-value crops, row covers or fully enclosed net houses can prevent pests reaching the crop. The size of the holes in the covers or net determines which insects can be excluded. Smaller holes usually mean less water penetration. The disadvantage is that, once a pest has found a way into the plants, its numbers might increase more rapidly in the absence of predators or it might be more difficult to physically control. Row covers and net houses do, however, offer other potential benefits such as providing a warmer environment and increasing the rate of plant growth; on the other hand, they can also increase humidity and the likelihood of fungal diseases developing. Row cover materials can be purchased from various horticultural suppliers, including Gundaroo Tiller (see Appendix A).
- *Soil solarisation*. Soil pests and some soil-borne diseases can be controlled by soil solarisation, which involves using sealed or overlapping clear plastic to heat the soil beneath to high temperatures, thus sterilising the top few centimetres of soil. Proper laying of the plastic and enough sun exposure to raise the soil temperature to a lethal level to the required depth are crucial. This technique has the advantage of sterilising the soil without fumigants but, like fumigation, it kills most living things (including beneficial soil organisms) and leaves the now-sterile soil open to colonisation by invasive and often pestiferous species.
- *Pupae busting*. 'Pupae busting' means cultivating the soil to destroy the exit holes for *Heliothis (Helicoverpa armigera)* moths after pupation. Normally it is done after harvest and before the over-wintering larvae or pupae are due to emerge as moths. Cultivation to a depth of 10 centimetres is sufficient. Although some pupae can be physically destroyed, the main purpose is to destroy the exit tunnels. Pupae busting is essential to keep the number of spring-emerging *Heliothis* to a minimum. Populations of *Heliothis*—particularly the tomato budworm or sweet corn earworm—grow exponentially with each subsequent generation, so reducing the initial numbers can make a big difference to the pressure in late summer or early autumn.
- Removal of pests. Sometimes only a small number of pests are in the crop and the crop area is relatively small. In this situation hand removal of pests is an option. Hosing plants down with water can also dislodge some pests and, if they are not very



RIRDC Pub. No. 07/153; $15.

mobile, prevent them from re-infesting the crop. Again, this is only possible in small intensive crop areas.

Biological control

Biological control uses beneficials, habitat manipulation and/or products derived from natural organisms to control pests. Natural enemies (beneficials) are organisms that feed on or otherwise kill the target pest. They can be predatory insects (including spiders and mites), parasitoids, fungi, bacteria, viruses, nematodes or animals (for example, insect-feeding birds). Biological control is often best used as a preventive method, but some components of biological control are useful as direct intervention.

- *Introduced beneficials*. Predators or parasitoids of a specific pest can be released into the problem area. Perhaps they are absent because they do not naturally occur in the area, for some reason they have been killed, or their populations are not sufficiently high to adequately control the pest. Some predator and parasitoid species are available from commercial insectaries to release into a crop to control a specific pest outbreak (see Appendix A).
- *Habitat manipulation*. Although this is normally a preventive method, slashing neighbouring insectary crops can encourage beneficials to move across into the target crop and perhaps control the pest. Yeast sprays can encourage lacewings and some other predatory bugs into a crop area to control a specific pest.
- *Autocidal control*. Autocidal control involves using mass-reared pest insects that are released after having been sterilised by radiation or chemosterilants. When the sterilised males mate with 'wild' females no progeny is produced. The success of this strategy is dependent on releasing enough sterile males into the natural population to outcompete or outnumber the natural or wild males and prevent the females reproducing. This is a tool being used in fruit fly control.
- *Semiochemical control*. Semiochemical control uses synthetically produced chemicals that imitate sex or aggregation (grouping) pheromones to disrupt the pest's behaviour. Both sex and aggregation pheromones can lure pests into a sticky or pesticide trap. Sex pheromones are also used to disrupt or prevent mating and reduce the number of pest offspring. This technique is commonly used in orchards and is more effective as a preventative method.
- *Biocidal control*. Biocidal control uses natural products or organisms that have a toxic or lethal effect on the target pest. Among such agents are products derived from plants (such as neem and natural pyrethrum), pathogens, bacteria, viruses, protozoa, fungi, nematodes and animals. In general, biocidal control can be used only as a direct control method once pest numbers have reached damaging levels since the kill rate is usually high but the carryover effect is low.

Chemical control

Chemical control is usually associated with synthetically derived poisons, which are not allowed under organic standards. Some chemicals are, however, permitted under organic standards, and these tend to be biologically derived or inorganic products or minerals. Some of the new generation insecticides are not clearly biologicals or synthetics and might be accepted under organic standards in the future.

It should be noted that even if the product is acceptable under organic standards it may not be legal to use it. As just noted, any insecticide, biologically based or not, is regulated by the Australian Pesticides and Veterinary Medicines Authority (APVMA) and each pest–crop–insecticide combination must be approved. Approved uses are clearly written on the insecticide label and any use contrary to those instructions is illegal. Table 4.2 lists examples of the common insecticide groups.

Table 4.2Common insecticide groups: some examples

Inorganics	Common synthetics	Biologicals	Others
Sulfura	Organochlorines	Rotenonea	Petroleum spray oils[b]
Copper sulphatea	Organophosphates	Ryaniaa	Vegetable spray oilsa—for example, Eco Oil®[c]
Arsenicals	Carbamates	Natural pyrethrum (non-selective) [a]	Soapsa
	Pyrethroids	Neema	Diatomaceous eartha
	Insect growth regulators	Bacillus thuringiensisa	Transgenics
		Insect viruses (non-GM)a	

[a]. Permitted in organic standards.
[b]. Some permitted in organic standards. Petroleum oils are not permitted for use on organic products exported to Japan.
c. Available from Organic Crop Protectants Pty Ltd (see Appendix A).
Source: S McDougall (2001).

4.9 Disease management

4.9.1 Causes of plant disease

Various members of the four major biological groups—fungi, bacteria, viruses and nematodes—cause plant diseases. The pest triangle (see Section 4.8) also relates to diseases. The pathogen, environment and host interact in disease expression. It is worth remembering, however, that symptoms resembling disease are often expressed but are the result of other factors such as nutrient effects.

Viruses

Viruses are micro-organisms that can infect plants and animals. Many viruses affect plants, and all of them need external agents, or vectors, for their transmission. Examples of vectors are insects, mites, nematodes and fungi; examples of insect vectors are thrips, aphids and leafhoppers. Some viruses have specific vectors—perhaps a certain type of aphid or fungus. There are no chemical treatments for viruses, which means the vector must be controlled if possible. Identifying viruses from plant symptoms is quite difficult, so if there are serious problems it is important that the virus be identified at a diagnostic laboratory.

Fungi

Fungi are microscopic organisms but have structures that can be seen with the naked eye. They produce hyphae, or strands, that can be seen on plant material. Their fruiting structures are visible with a hand lens or microscope, and their spores can be carried by wind or spread through water. These spores usually require moisture—rain, dew or high humidity—to germinate and infect plants. Some fungi have a narrow host range; others have a wide host range. Downy mildew is the collective term for a disease that affects a wide variety of plants, but separate species infect different plant groups. The downy mildew that affects grapes does not affect lettuce, for example. Many soil-borne fungi are important in breaking down plant material and are an important part of soil biology.

Bacteria

The bacteria that cause diseases in lettuce are single-celled organisms and do not form more complex structures such as those developed by fungi. There are no multi-celled hyphae or hard-walled resting spores (sclerotia), so the bacteria need other entry points. Bacteria can be secondary invaders of plant tissue when they invade damaged tissue. The initial damage can be caused by insects, other pathogens, frost, herbicide or hail. Other entry points for bacteria are stomates and lenticels, natural openings found on the leaf surface. Unlike fungi, which have spores that can be spread by the wind, bacteria must be transported by other means—for example rain, insects, pruning and cutting implements, machinery, moving soil and water. In lettuce production bacteria can be spread from one head to another during harvest.

Nematodes

Nematodes are very small worm-like animals, too small to be seen with the naked eye. Some types are pathogenic; others are beneficial and consume pathogenic fungi; yet others contribute to soil biological activity. Pathogenic-type nematodes have a mouthpart that pierces plant cells for feeding. As a consequence of this feeding, the plants can become stunted and die. Nematodes are usually associated with plant roots, but some species affect other plant parts. Nematodes tend to be more of a problem in light-textured soils such as sand.

4.9.2 Diagnosis

Different diseases require different treatments. Publications on plant diseases might help with diagnosis; otherwise, there are plant disease diagnostic services in each state (see Appendix A). Control recommendations cannot be made unless the problem has been accurately diagnosed. Disease control will not be successful if the disease has not been correctly identified.

The various diagnostic services available might charge a fee, but using them can save time and money: unnecessary sprays will be avoided and the right spray for the disease can be chosen.

4.9.3 Reducing plant diseases organically

It is important to have a complete picture of what diseases occur in a particular region. Some regions may not have a serious disease: for example, white rot of onions does not occur in the Murrumbidgee Irrigation Area, whereas it is a serious disease in other growing areas.

The proposed cropping site should not have a history of any serious soil-borne diseases. Ask the district horticulturist what diseases could cause trouble for the proposed crop.

Variety selection

When choosing the correct variety for the area, account should be taken not only of optimising yield but also of maximising disease control. There are two ways a variety can help disease management:

- varietal resistance and tolerance
- the physical shape or habit of the plant.

A variety can have genetic resistance to a disease; that is, it has been bred to be resistant to the disease. For example, resistance to downy mildew has been bred into some

lettuce varieties. Varieties can also show reduced or increased disease levels as a result of their physical characteristics. Plants might not be completely resistant to a disease but can be tolerant.

Pathogen-free seed or vegetative propagation material

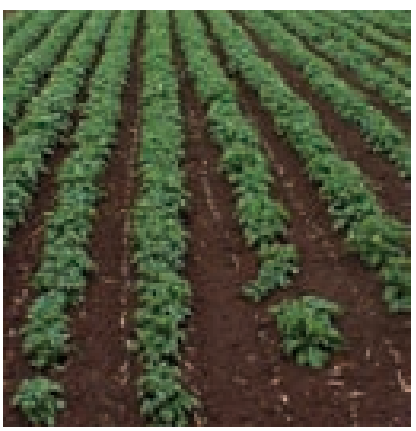
Many viruses are seed borne. Potatoes are a good example of vegetative material capable of carrying pathogens. Make sure any planting material is free of diseases. Always keep a small amount of the material for reference in case problems are found after planting.

Climate

Many plant diseases are affected by environmental conditions. High rainfall—or, more specifically, high leaf wetness—can promote infection with many of the fungal diseases, such as downy mildews and rusts. Reducing the plant density can increase the air flow through the crop, although this could compromise weed management.

Weed control

Weed control is important for many plant diseases because often the weeds are also the hosts of the diseases. Many weeds and ornamental plants are hosts of tomato spotted wilt, which is a virus affecting tomatoes. The virus is transmitted by thrips.



Potato crop

Crop rotation

Changing the crops grown has long been a way of reducing diseases. It can be important in controlling many soil-borne diseases, but it will not have an effect on soil-borne diseases that produce inoculum that can survive in the soil for many years. Fungi that produce sclerotia (hard-bodied survival structures of some soil-borne fungi) are an example of this.

Rotation will be successful if the disease in question survives only on host material and does not survive when all residue of that host is absent. For example, in a rotation with lettuce it is important not to have a crop that is also a host of *Sclerotinia minor*.

Roguing

'Roguing' means physical removal of any diseased plants. The practice can reduce both the spread of the disease and the carryover of the disease. It can be labour intensive, though, so might be of benefit only in high-value crops. Using lettuce as an example, removing plants that sclerotia have developed on will help to reduce the overall amount of sclerotia that could end up in the soil for future infection.

Removal of crop residue

Removal of crop residue is very important if overlapping of plantings occurs. In lettuce production, lettuce is planted in overlapping plantings so that a continual supply is available. Once a block is harvested, plant material should be ploughed in. As a last resort, burning the plant material—something not favoured in organic standards—can help reduce the carryover of disease. Grazing livestock such as poultry can help to remove crop residue.

Irrigation management

Overhead irrigation can contribute to plant foliar diseases. If it is used, make sure that plants dry out as quickly as possible—for example, by avoiding watering in the evening, so that foliage does not remain wet overnight.

Trickle irrigation is the best option for reducing plant disease. Flooding can, however, be used to limit some diseases (such as sclerotia) before planting a susceptible crop.

Over-irrigation can cause serious problems by favouring soil-borne diseases.

Soil solarisation

Solarisation is discussed in Section 4.7.

Soil management

Improving soil health through increasing biological activity can reduce the chance of soil-borne pathogens being a problem. Addition of compost and incorporation of green manure crops can help reduce soil-borne diseases by increasing the biological activity of beneficial species in the soil. Careful selection of the green manure is important, to ensure that it, too, is not a host to the pathogen.

Ploughing

Ploughing can be useful for burying sclerotia and subsequently increasing the biological breakdown of the survival structures.

Biological control

Research into biological control is expanding rapidly, and growing numbers of micro-organisms for biological control of soil-borne diseases are being developed. *Trichoderma* (a common soil-borne genus of fungi) species have been developed to control soil-borne plant diseases.

Fungicides

A number of organically acceptable chemicals are available if disease control is necessary



Zuchini leaves with powdery mildew

(see Appendix B). Among them are copper, lime sulphur, sodium bicarbonate, sulphur and vegetable oils. These products are effective only against foliar plant pathogens. Copper is useful against downy mildews and bacterial diseases; sulphur is effective against powdery mildews. Note that both copper and sulphur are currently under review for use in organic systems, and using alternatives to them might become necessary. A review of alternatives to copper for disease control in organic systems has been undertaken by Van Zwieten et al. (2004).

Other organic sprays

Among other possibilities for disease control are products still under evaluation, such as compost teas and milk. Evidence suggests that both these products are efficacious for certain diseases. Milk has shown some effectiveness against powdery mildew. Many organic farmers believe that, by stimulating the natural defence mechanisms in plants and animals, resistance to disease can be strengthened. Some commercial products are marketed on this principle; examples are seaweed extracts such as Acadian SSE®, a product of Organic Crop Protectants Pty Ltd (see Appendix A).

4.10 Economics

When determining the economics of organic vegetable production it is necessary to take into account not only the profitability of growing the particular crop but also the profitability of the entire rotation.

As a result of trials conducted at the NSW Department of Primary Industries organic demonstration site at Yanco, some indicative gross margin budgets have been developed; these are shown in Tables 4.3 to 4.6.

When interpreting these budgets, several important points need to be taken into consideration:

- The data are site specific. The yields obtained and management practices used are appropriate only for the Yanco organic demonstration site; data should be modified to reflect different management regimes and sites.
- Returns for produce are those quoted by an organic wholesaler for certified organic produce at the time of sale. Prices will vary from season to season and will generally depend on supply at that particular time and in that particular market.
- Gross margin budgets are only an indication of potential costs and returns for an enterprise in any particular year. Factors such as climactic variability, management expertise and market fluctuations will vary the budget.



Prices will vary from season to season and will generally depend on supply at that particular time and in that particular market

Table 4.3 Indicative gross margin budget: organic rockmelons

	Standard budget ($/ha)
Income	
Yield1600 cartons @ $13/carton	20 800.00
Total income	**20 800.00**
Operation	
Land preparation	
Rip	55.00
Disc (2)	27.50
Grade	11.00
Broadcast	7.00
Bed form	20.63
Incorporate	27.50
Fertiliser	
Compost (8 t/ha)	120.00
Rock phosphate	45.50
Green manure (grow and incorporate)	283.50
Planting	
Sowing	20.63
Seed	450.00
Growing	
Mechanical cultivation (2)	68.76
Boomspray (foliar 4)	27.5
Fertiliser	
BD500	2.00
Foliar biological spray (3)	39.42
Weed control	
Casual labour (hoe) 35 hrs	420.00
Irrigation (drip)	90.44
Harvesting	
Contract pick, sort and load	2 450.00
Trailer use	137.50
Casual labour	120.00
Bins hire	352.80
Grade, pack	1 425.00
Cartons	3 287.00
Machine operation	87.50
Total variable costs	**9 576.18**
Gross margin/ha	11 223.82
Gross margin/mL	1 603.40

Source: NSW Department of Primary Industries

Table 4.4 Indicative gross margin budget: organic sweet corn

		Standard budget ($/ha)
Income		
Yield	11.3 tonnes/ha @ $143/tonne	1 615.90
Total income		**1 615.90**
Operation		
Land preparation		
Incorporate green manure		16.07
Deep rip		17.31
Scarify (2)		24.72
Hill up		12.36
Bed form		12.36
Fertiliser		
Apply and spread compost	16 tonne/ha	255.00
Gypsum	0.5 tonne/ha	23.00
Lime	0.3 tonne/ha	13.50
RPR	100 kg/ha	25.00
Spreading		7.50
BD500		6.95
Foliar (3)		67.05
Biological spray		14.95
Planting		
Seed	15kg/ha	240.00
Sowing		12.36
Seed treatment		3.20
Weed control		
Interrow cultivation * 2		61.88
Pest control		
Gemstar® (permit required)	0.8l/ha @ $60/l	48.00
Aerial spray (Gemstar®)	$12/ha	12.00
Irrigation		
8 mL/ha @ 17.36/mL		148.00
Harvest		
Contractor	11.3 tonne @ $16/tonne	180.80
Hire of two bin trailer		48.80
Total variable costs		**1 250.81**
Gross margin/ha		365.09

Source: NSW Department of Primary Industries

Table 4.5 Indicative gross margin budget: organic pumpkin, Jarrahdale

		Standard budget ($/ha)
Income		
Yield	30 tonnes/ha @ $400/tonne	12 000.00
Total income		**12 000.00**
Operation		
Land preparation		
Rip		27.50
Disc (2)		27.50
Grade		12.14
Direct drill		6.88
Bed form		20.63
Fertiliser		
Compost		120.00
Rock phosphate		45.50
Green manure (grow and incorporate)		283.50
Planting		
Sowing		20.63
Seed		60.00
Growing		
Mechanical cultivation (WeedFix 2)		61.88
Rehill		13.75
Boomspray (3 foliar)		20.63
Fertiliser		
BD500		2.00
Foliar biological spray (3)		39.42
Weed control		
Casual labour (hoe)	35hrs	420.00
Irrigation		77.52
Harvesting		
Contract pick, sort and load		1,375.00
Bins (large)		990.00
Freight (Sydney)		2 420.00
Total variable costs		**6 044.48**
Gross margin/ha		5 955.52
Gross margin/mL		992.58

Source: NSW Department of Primary Industries.

Table 4.6 Indicative gross margin budget: organic pumpkin, butternut

		Standard budget ($/ha)
Income		
Yield	1050 cartons/ha @ $16 /carton	16 800.00
Total income		**16 800.00**
Operation		
Land preparation		
Rip		27.50
Disc (2)		27.50
Grade		11.00
Direct drill		7.00
Bed form		20.63
Fertiliser		
Compost		120.00
Rock phosphate		45.50
Green manure (grow and incorporate)		283.50
Planting		
Sowing		20.63
Seed		150.00
Growing		
Mechanical cultivation (WeedFix 2)		82.50
Rehill		20.63
Boomspray (4 foliar)		27.50
Fertiliser		
BD500		2.00
Foliar biological spray (3)		39.42
Weed control		
Casual labour (hoe)	35 hrs	420.00
Irrigation		90.44
Harvesting		
Contract picking		1 666.75
Wash, grade, pack		1 440.00
Cartons		1 995.00
Freight (Sydney)		1 155.00
Total variable costs		**7 652.50**
Gross margin/ha (A – B)		9 147.50
Gross margin/mL		1 306.79

Source: NSW Department of Primary Industries.

5. Organic vegetable case studies

The case studies that follow have previously been published as part of the NSW Agriculture Agfact series. They provide examples of the organic production requirements for a range of vegetables. The crops chosen reflect the growth patterns of three production systems—perennial (asparagus), broadacre annual (pumpkin) and intensive annual (tomatoes). Many of the organic practices used in the production of these crops are applicable to other vegetable and herb crops.



Asparagus



Pumpkins



Tomatoes

5.1 Organic production of asparagus

Introduction

Asparagus has few pest or disease problems and can be grown without artificial pesticides, making it a relatively easy crop to grow organically. Good weed management, particularly during establishment, is essential to promote healthy growth and satisfactory yield and quality.

Organic asparagus production, like other vegetable production systems, involves developing a functional system that provides adequate fertility while maintaining effective weed management. A well managed asparagus stand may stay productive for 15 years or more.

An understanding of the annual growth habit will help in planning an organic management program.

Growth habit

Asparagus is a perennial plant. It produces dark green fern-like foliage during summer and in cooler climates becomes dormant over winter months.

Asparagus spears begin as leaf buds below the soil surface, elongating to form the spears above ground as temperatures warm in the spring. These are then cut during harvest, making way for new spears to initiate from buds on the crown below the soil. Harvesting of the spears continues until spear quality deteriorates (during hot weather) or market prices fall.

When harvesting ceases, the spear is allowed to develop into its fully expanded leaf, or fern. During this stage the plant photosynthesises and replenishes its nutrient reserves in the crown for the next year's harvest. In colder districts, the asparagus fern will 'die off' during winter in similar fashion to a deciduous tree.



Asparagus can be a relatively easy crop to grow organically

The fern is then mulched into the soil or removed in preparation for harvest of the new asparagus spears in spring. The fern is not removed until completely 'dead' so that the asparagus root or crown is replenished as nutrients are reabsorbed from the stem and foliage. This step is followed by a shallow cultivation prior to spear emergence to incorporate the trash, clean up weeds and provide a clear surface for harvesting.

Variety selection

Potential growers will need to source an asparagus variety that has market acceptability, is suited to your local climate and, ideally, and if possible, is raised organically (this is a requirement of the National Standard for Organic and Bio-Dynamic Produce).

Some varieties will be more suited to processing; others to the fresh market. Will you grow green or white asparagus? Many European varieties are unsuitable for warmer inland and northern districts as the spears tend to lose quality as the leaf bracts open prematurely in the hotter weather. Research has shown that certain Californian varieties are best suited under these conditions.

Select varieties that have been bred for disease resistance, specifically *Fusarium sp.* and *Phytopthera sp.* resistance.

Pre-planting and establishment

Establishment is the critical growth stage for asparagus. Seedling transplants are common, although these are relatively slow to establish and full production can not be expected for at least three years. Crowns are more reliable and may yield earlier depending on crown size. The young crowns are usually planted in a shallow trench which is gradually filled in as the crown matures. This leaves the asparagus growing on a low mound (the mound is higher for white asparagus).

Crop nutrition and soil management

Asparagus grows in a wide variety of soils but grows best in a light well-drained soil with a high nutrient content. Deep alluvial soils provide optimum conditions for growth. However, these soils can be prone to erosion, low in organic matter and may be leached of essential nutrients.

The soil should be analysed for its nutrient status well before planting to determine pre-planting nutrient requirements and a fertility program should be implemented at least 2 years before planting.

If a green manure crop is to be grown as part of the fertility program it will require incorporation well before planting so that organic residues are properly decomposed. Compost is an excellent soil amendment and should be considered an essential addition pre-planting, with annual applications for the established asparagus stand.

Fertiliser recommendations vary with soils and growing conditions, but as a general guide NSW asparagus producers apply 150 kg actual nitrogen (N), 50 kg actual phosphorus (P) and 50 kg actual potassium (K) per hectare per year to asparagus.

An incorporated green manure crop can supply from 80 to 150 kg actual N per year, while composted cow manure (analysed at 2% N on a non-dry weight basis), applied at 6 tonne / hectare / annum, could supply 120 kg actual N. Because of variability between batches of compost each should be separately analysed for nutrient content. If externally sourced, you should also test for heavy metals.

Phosphorus should be applied as Reactive Phosphate Rock (RPR) a season prior to planting as well as under the plants at planting and in each year of production. RPR should be checked for cadmium. Levels should not exceed 20 ppm – mg/kg in fertilisers or manures.

Potassium can be supplied organically through composts and seaweed extracts.

Commercial organic fertilisers that can supply most nutrients are available, but these must be carefully evaluated for cost and effectiveness. Some organic certification organisations have approved a range of commercial organic fertilisers. Reliance on these, as opposed to good soil management practices (green manuring and use of compost) is discouraged.



Compost is an important addition to an organic soil management program. Loading compost for spreading at the Yanco organic demonstration site. Source: NSW Department of Primary Industries

Annual fertiliser applications should be applied prior to the pre-harvest cultivation.

Research has shown that N, P, and K extraction by crops is in the vicinity of 34, 6 and 18 kg/Ha, respectively, so you should aim to replace these amounts annually. Allowances should also be made for other losses to the system such as those from leaching, surface run-off and volatilisation evaporation) of nutrients.

Research has also shown that asparagus seedlings are particularly sensitive to deficiencies in magnesium, calcium, copper and sulfur.

A nutrient budget can help you to assess your crop's nutritional requirements a couple of seasons in advance, and helps to identify potential losses and gains of nutrients to the system. Table 1 gives an example of a possible budget for nitrogen inputs in asparagus production.

Table 1. Estimated annual nitrogen budget for 1 Ha asparagus, green manured and fertilised with composted cow manure

Input / Losses	kg actual N /ha / year
I. Inputs	
a) Gains that remain in the soil and in crop residues:	
N in green manure crop (clover/vetch)	140b
N in rain	8 c
N2 fixation (non-symbiotic)	5 c
	subtotal 153
b) Gains in composted cow manure applied @ 6 tonnes / ha (analysed at 2% N on dry weight basis)	120 d
	subtotal 120
Total input	**Total gains 273**
II. Losses in the field	
sale of spears (yld 8t/ha, untrimmed)	34 e
fern removal	negligible as most nutrients returned to crowne e
composted manure	2 b
leaching, surface run-off and volatilisation	200 c
Total Losses	**Total losses 236**
III. Net accumulation of N in soil	**Net +37kg N/Ha**

Sources: a Alenson, 1989; b Lampkin, 1990; c Kaffka and Koepf, 1989; d Analysis Rockdale Feedlot Pty Ltd. Based on 2% N on dry weight basis.1993; e Prior, L. Nutrition of Asparagus. Paper presented at 'Asparagus Growers Seminar, 1988'. Wagga Wagga, NSW. Dept of Agriculture, NSW and Vic. Dept.of Agriculture and Rural Affairs.

Weed management

Weed control is critical during asparagus establishment and is best started well before planting. This involves selecting an area with few weeds and using cultivation and sowing activities to encourage pre-planting germination of weed seeds. Green manure and cereal crops planted prior to asparagus will help to out-compete weeds as well as adding to soil organic matter and fertility levels. Difficult to control weeds may need to be removed by hand.

Weed management following planting can be difficult as the young asparagus plant lacks vigour and the competitiveness of a mature stand.

Mulch can be applied around seedlings. Research has shown that mulches such as straw, sawdust and bark spread at 100mm depth can provide adequate to good control of weeds. In cooler districts, mulching may delay the emergence of spears in spring and prolong harvest later in the season due to its cooling effect on the soil. This may be advantageous if a later harvest gives you a market niche, or disadvantageous if there is a market glut. Mulch may also increase the risk of frost damage to emerging spears.

Weed control during harvest (particularly self-sown asparagus) needs to be achieved.

Flaming weeds is an option prior to spear emergence. A clean-up during harvest could also be achieved by removing all spears protruding above the ground and then flaming the weeds. Note that flamers are most effective on newly emerged weeds.

Grazing animals while the asparagus is dormant will also help to control weeds and provide additional nutrient benefits in the form of manure. Sheep and weeder geese can be used effectively, while ducks – as well as eating weeds – will also consume snails and insects.



Properly timed, gas flaming can be an effective weed management tool in an organic growing system.
Photo: R. Neeson

Intercropping

An asparagus crop will not reach full productivity for at least three years, so returns will be relatively low during the establishment years. The delay in economic return could be partially offset by intercropping between the asparagus rows with other vegetables or herbs. Planting an intercrop also helps reduce weed problems in the inter-row area.

Any intercrop requires good nutrition and water management to reduce competition with the asparagus, and care is needed to ensure the crop does not host pests or diseases of asparagus.

Intercropping of asparagus with a low-growing leguminous cover crop can be effective in reducing inter-row weeds, providing nutrition to the asparagus and improving soil structure. Research has shown that there may be a competitive effect from cover crops during the establishment year and the first few years following transplanting the asparagus. Supplying ample nutrition and water to the cover crop may reduce this impact.

Two potential cover cropping systems could be adopted. The first type involves planting a low-growing perennial cover crop, such as clover, that is mulched or slashed regularly for optimum benefit. A side-throw mulcher, slasher, or alternatively a forage harvester could be used, with the cuttings directed around the asparagus plants. This provides a nutrition and mulch benefit to the asparagus plants.

If using this system, sufficient distance must be retained between the asparagus rows to allow for machinery operations such as slashing of the asparagus fern in winter, cultivation of weeds and harvest preparations. Cultivation over the crop row should be shallow or avoided altogether to avoid damaging the crowns. Soil may need to be hilled up over rows to increase depth.



A green manure crop ready for incorporating. This crop is oats, faba bean field peas and mustard.
Photo: R. Neeson

An alternative cover cropping system involves sowing an annual cover crop following removal of the fern in winter and incorporating it as a green manure or slashing / mulching it prior to spear emergence in the spring.

Regardless of the system decided upon, it is imperative to have the cutting zone free of weeds and trash during harvest.

Pests and diseases

Asparagus has few pest and disease problems.

The most significant insect pests are thrips and Rutherglen bug (*Nysius vinitor;* Lygaeidae). Both are difficult to predict and control, usually appearing 'overnight' in swarms.

Thrips are very tiny, slender insects that may feed on developing spears, causing distortion. The onion thrips (*Thrips tabaci*) is the most common. Thrips are most likely to migrate to asparagus when plants they have been feeding on have matured or dried out. A large number of weeds and ornamentals (particularly perennials) are known to host thrips, and whilst removal of host weeds will reduce the chance that thrips may become a problem, this may not be a practical solution. Anecdotal evidence suggests basil may help to repel thrips.

Releasing predatory insects may reduce thrips numbers. Effective predators include predatory mites (*Amblyseius*) and green lacewing (*Mallada signata*). Releases should begin early in the season and may need to be made several times. Pest and predator populations should be monitored regularly.

A number of organic sprays can be used successfully to control thrips including soap, natural pyrethrum (will also kill beneficial species) and horticultural mineral oils.

The Rutherglen bug usually breeds in the seed heads of weeds and from here they move to agricultural crops. In some years they may reach plague numbers in spring and summer. Management is best achieved by removing host weeds such as Paterson's curse from areas surrounding the crop.

Minor damage due to red legged earth mite and two-spotted mite has been reported. Removing or slashing green manures prior to harvest may worsen mite problems as they could migrate onto the asparagus.

Snails and slugs can occasionally damage spears. Ducks introduced into the system consume these and some weeds, but are less likely to eat the asparagus.

Fusarium sp. and *Phytopthera* sp. are two fungal diseases commonly reported in conventional asparagus production. With good soil and irrigation management, the use of resistant varieties and the use of well-grown nursery stock, these are less likely to be a problem.

Stemphylium sp is the fungus that causes fern spot of asparagus. It commonly occurs in showery weather or where overhead irrigation is used. Symptoms include purple spots on ferns and spears. Removing old ferns will help to reduce the level of this disease.

Three new diseases have recently been recorded on asparagus in Australia. Asparagus stem blight (*Phomopsis asparagi*) has been found in Queensland and Victoria. Stem blight causes defoliation and loss of production and is a very difficult disease to manage. Asparagus rust (*Puccinia asparagi*) has only been found in Queensland. The rust weakens plants and reduces marketable yield. Anthracnose (*Colletotrichum gloeosproioides*) can be a devastating disease and has been found in Queensland and the Northern Territory. Anthracnose produces large lesions on the fern stems.

Harvesting

The harvest season for asparagus extends from August in warmer districts through to December in cooler districts. Harvesting has been extended using crop manipulation techniques such as 'mother fern culture'. In this system, one spear is permitted to proceed to fern, while other spears in the crown continue to be harvested. The 'mother fern' provides some supplementary nutrition, slightly prolonging the harvest. This method of extending the harvest, however, may affect crown longevity and, thus, the total productive potential of the asparagus stand.

Harvesting is performed during the early morning when it is cool. Spears are cut just below the ground when 200mm or greater of the spear is protruding above the soil surface. Spears are later trimmed to 180mm. Spears are then collected and kept in the shade until removed from the field.

Post-harvest management

Asparagus spears deteriorate rapidly and must be cooled as soon as possible after harvest. Once in the packing shed, field heat should be removed. This should occur immediately if the spears are not being graded and packed straight away.



Bio-dynamic asparagus packaged for market.
Photo: R. Neeson

Hydro-cooling is the usual method used to pre-cool spears to remove



If spears are dirty they should be washed, preferably with chilled water, prior to packing

field heat. This involves spraying, flooding or immersing the spears in chilled water (3°C-5°C). The spears are then placed directly into a cool room. Length of time to leave the spears in the hydro-cooler depends on the temperature and flow rate of the cooling water, the initial temperature of the spears and whether the spears are loose or packaged.

Hydro-cooling usually involves recirculation of water and this may cause an accumulation of micro-organisms. In conventional production systems active chlorine at a rate of 200 – 400 $mg.l^{-1}$ is usually added to the holding tank. However, organic standards do not permit the use of chlorine above 5ppm. Hydrogen peroxide (H_2O_2), another effective disinfectant, is permitted in organic standards. Research has shown that 5% H_2O_2 is a reasonably effective anti-microbial agent. However, further research is necessary to determine the usefulness of H_2O_2 treatment.

If spears are dirty they should be washed, preferably with chilled water, prior to packing. Spears will need to be trimmed, graded and bundled according to the requirements of your markets. Conventionally, it is common practice to dip the butts immediately after cutting and bundling into a solution of calcium hypochlorite to prevent bacterial soft rot, but this is not permitted in organic production systems. The use of hydrogen peroxide should be investigated as an organically acceptable alternative to calcium hypochlorite.

Bundled spears should be packed in fully waxed, paper-lined cartons. If already pre-cooled, spears should be packed as quickly as possible and cartons placed into a coolroom set at 2°C.

Refrigerated transport should be used to ship asparagus to market. Transport operators should be made aware that your produce is organic to avoid the possibility of contamination.

Marketing

The market possibilities for asparagus producers include fresh or processed, local or export, white or green, spears or tips. Quality and continuity of supply are the keys to success.

Fresh asparagus is most likely to fall victim to oversupply. While the harvest period can be extended or manipulated through various cutting strategies, the only other opportunity to avoid peak supply times arises if your particular climate favours slightly out-of-season production.

Check with wholesalers to determine when periods of under-supply and oversupply occur. New Zealand organic asparagus is available from October through to January.

Contacts

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5.2 Organic production of pumpkin

Introduction

Pumpkins are a good choice for the grower who is considering organic vegetable production, as they may be included early in rotations or in a conversion plan. Other vegetables in this category include squash, gourds, cucumbers, rockmelons and watermelons.

Given favourable growing conditions, organic pumpkins will yield around 40 tonnes to the hectare, are relatively easy to store, handle and transport and, if markets are not over-supplied, can provide a good return for producers. The organic market should be well researched as oversupply is a danger.

Variety selection

Markets should be assessed prior to planting to determine consumer preference. Butternuts, Jarrahdale and Jap pumpkins are commonly grown. Organic markets may prefer some of the older varieties, while processors may be quite specific in their requirements. If over-supply occurs, you may have to sell your produce on the conventional market. With this in mind, you may wish to consider growing varieties such as Japanese hybrids that sell well in conventional markets.

Varieties will differ in their yielding ability, vigour and pest and disease resistance so it is advisable to investigate how the variety selected performs in your region. The growth characteristics of the variety will also determine cultural aspects such as planting distance.

Production of pumpkins is usually from seed sown directly in the field. The National Standard for Organic and Bio-Dynamic Produce requires seed to be organically produced, unless suitable quantity and quality is unavailable, so a reputable supplier will need to be found. Records proving that an effort has been made to source organic seed must be provided to the organic certifier. If an open-pollinated variety is grown it will produce seed that will breed true to type provided cross-pollination with other pumpkin or squash varieties does not occur) so, alternatively, you could raise and collect your own seed.



Pumpkins can provide a good return for producers

Rotation design

Pumpkins prefer a high nutrition regime that would generally follow a green manure (legumes and grasses) or an intensive composting program. Pumpkin's spreading growth habit and leaf size gives it a competitive advantage over weeds, and provides an opportunity as a 'cleaning' crop to precede a less competitive vegetable such as onions in the rotation. Potatoes are another excellent cleaning crop and if grown back-to-back with pumpkins in a rotation can provide a good preceding rotation for root crops, which are among the most difficult of vegetables to keep weed free

To minimise the risk of disease carryover, pumpkins ideally should not be grown where another member of the cucurbit family e.g., watermelons, cucumber, zucchini, has been grown in the previous year.

Organic standards require that no annual crop of the same species, family, or similar characteristic be planted for more than 2 years out of 5 within the rotation. Furthermore, the standards require that a green manure, annual legume or pasture ley phase be grown at least one year in three, except where soil fertility and structural characteristics are entirely met by the importation of composted manures or other permitted varieties of organic matter.

Ground preparation and planting

Like other vegetables, good seedbed preparation is essential for pumpkin production. The seedbed should be weed free and reasonably clod free.

Pumpkins are generally grown on well-formed beds. Following green manure incorporation and scarifying, the field is hilled and, if compost is to be applied, it is deposited between a series of hills, which are later combined to form a bed. This places the compost directly below the planting row, allowing the pumpkin immediate access to the compost as it grows into it.

Alternatively, compost application could be split, with half applied and incorporated during primary tillage, thus facilitating decomposition of the green manure, and the remainder applied during bed forming or surface-applied following planting.

Seed is normally sown direct, when the risk of late frosts is well past and when soil temperatures have warmed (a minimum of 15°C). In inland New South Wales sowing begins in early October.

When planted in continuous rows the seeds are sown rather thickly, and when the pumpkin plants are at the 3 to 4 leaf stage, they are thinned to 0.8 – 1.3 metres apart within the row.



An organic pumpkin crop at NSW Agriculture's organic demonstration site at Yanco. Pumpkins are a good choice to include in an organic rotation, early in the conversion phase. (R. Neeson)

Crop nutrition

Achieving good yields of a quality product will depend on achieving a balance of soil elements, good organic matter and a biologically active soil.

Pumpkins will tolerate slightly acid conditions but prefer soils that are high in organic matter. Compost applications of around 10 tonnes / ha are commonly incorporated with green manure prior to cropping.

A soil test should be carried out following green manure incorporation and prior to planting to determine the crop requirements. Pumpkins are relatively heavy nitrogen feeders and since N in compost is slowly available, an additional application of a commercial organic fertiliser may be required at planting.

Foliar applications or fertigation (applied through a micro-drip irrigation system) with approved organic products can be used to correct temporary nutritional deficiencies. A foliar application of fish emulsion, seaweed or garlic extract may also help to repel certain pests.

Weed management

The most critical period for effective weed management is prior to crop establishment.

Pre-irrigation or rainfall will germinate weeds, after which a shallow cultivation or flaming will remove weeds prior to sowing.

Weeds need to be kept in check until the pumpkin vines have covered the beds. This can be achieved either by removing weeds by tillage with an implement such as the WeedFix® (see photo) hand weeding or mulching the entire bed. Mulching can provide additional benefits including moisture retention and can provide a 'clean' barrier between fruit and the bare soil, thus preventing staining of the underside of the pumpkin.

Hand weeding during early crop establishment is the usual method of intercrop (between plants within a row) weed management, since weeds are difficult to control with cultivating implements without damaging the crop. Thinning time provides an opportunity to remove weeds that have grown within the crop row.

Pests and diseases

Pests

Significant pests of pumpkin include the 28-spotted ladybird (*Epilachna* spp.) and the pumpkin beetle (*Aulacophora hilarus*). Both these pests have a migratory habit, often flying in to a crop in large numbers from weeds or other nearby crops. They are most likely to be a problem during establishment when plants are small (during this stage they may skeletonise a young plant) and during flowering when fruit set may be affected. Older plants can generally tolerate a larger pest load.

Crops attractive to pests should not be grown adjacent to the pumpkin crop and should be avoided prior to the pumpkin crop being planted. Removing host weeds also helps to reduce problems. Alternatively, some plants may be more attractive to these pests and these may be strategically planted to act as a trap crop to draw the pests from the commercial crop.

Established organic producers often suggest that plants that are attacked by pests are suffering some form of stress. This could be moisture stress or a nutritional deficiency. Irrigation should be monitored to avoid moisture stress, while a leaf sap or tissue analysis can determine the nutritional status of the growing crop.

Some naturally derived pesticides are permitted for use in organic standards. However, this use should not be the primary form of control. Care should be taken when using these products as some may be toxic to non-target species and may also affect human health.

Diseases

Powdery mildew

The most common disease affecting pumpkins in inland areas is powdery mildew (*Oidium* sp.). Powdery mildew generally does not require moist conditions to establish and grow, and normally does well under warm conditions; thus they are more prevalent than many other leaf-infecting diseases in the dry summer conditions of inland NSW.



Powdery mildew

Powdery mildew first appears as white powdery spots that may form on both surfaces of leaves, on shoots and sometimes on flowers and fruit. These spots gradually spread over a large area of the leaves and stems. Leaves infected with powdery mildew may gradually turn completely yellow, die and fall off, exposing fruit to sunburn. Severely infected plants may have reduced yields, shortened production and fruit with little flavour.



An oat crop that has been slashed to form a mulch over beds prior to sowing at Yanco. Photo: R. Neeson

Planting varieties that are least susceptible to powdery mildew is the primary method of control. Varieties differ in their susceptibility and seed companies should be able to provide you with a resistance rating for your chosen variety.

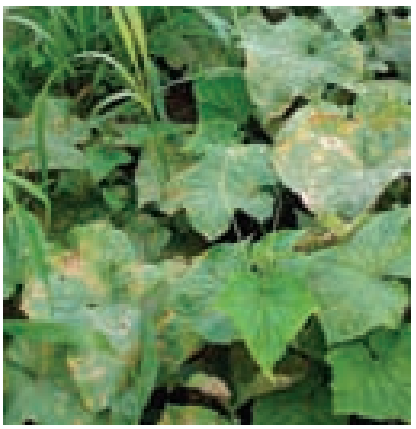
Old crops that are infected should be ploughed under as soon as possible following harvest. Crops should be rotated every 3 to 4 years and growers should avoid planting a new crop right next to an older, diseased crop.

Seed should only be saved from healthy fruit.

Downy mildew

In coastal districts downy mildew (*Pseudoperonospora cubensis*) is more common and is favoured by cool, wet weather. Symptoms are yellow leaf spots that soon turn brown. Faint purple spore growth develops on the lower leaf surface and if the spots are numerous, the leaf shrivels and dies. Control is usually achieved organically with copper sprays (note that under the national organic standards this is restricted use).

The web site http://www.attra.ncat.org/attra-pub/PDF/downymil.pdf provides organic control options for powdery mildew in cucurbits.



Downy mildew in cucmber crop

Other problems

Failure of pumpkins to set fruit is usually as a result of inadequate pollination and / or excessive amounts of nitrogen in the soil. Bee hives can be hired for the season from bee keepers: 2 – 3 hives /ha is needed to ensure good pollination.

Harvesting and marketing

Following hand removal (cutting) of the vines, pumpkins may be field cured or cut from the vines and cured in well-aerated bins in storage. A light frost will kill off vines and facilitate harvest by exposing the fruit. There is some anecdotal evidence to suggest that allowing the vines to be frosted may also improve the flavour of the fruit. Heavy frost, on the other hand, may damage the pumpkin skin, especially thin types such as butternuts, leading to fruit breakdown.



Pollination is needed to set the pumpkin fruit

A field elevator will assist in lifting fruit from the field and into field bins.

Bins should allow for adequate aeration and should be removed to the packing shed as soon as possible.

Packing and storage

Once cured, the pumpkins should be graded and packed according to market requirements. Wholesalers usually prefer fruit packed into bulk cardboard bins.

Boxes or cartons should be labelled with your name, certification number, the certifier's logo, date packed, batch number (if selling in batches), variety and grade.

Pumpkins will store up to three months, depending on variety and storage conditions. Only sound fruit should be stored and these should be checked regularly and any rotting fruit removed. Butternuts should not be stored under cold conditions.

Marketing considerations

Storage will allow marketing over a period of time. This may help to avoid market oversupply. If other growers are supplying the market at the same time, it may be worthwhile coming to an agreement whereby supplies of produce into the market are alternated between growers. By doing this, all growers may receive better market prices.



Organic baby food is among the products made from organic pumpkins. Source: <http:// www. GoodnessDirect.co.uk.>

Pumpkins are also processed into frozen, pureed for baby food and pie fillings, made into jams and used in dried products. Value-adding pumpkins could be done on-farm (facilities will need to be inspected by the certifier and will need to meet health standards) or by a certified processor. If supplying a processor, their requirements (such as variety, size and maturity at delivery) should be determined prior to planting.

The economics of organic pumpkin production will depend on costs of inputs (labour, fertiliser) the yield, quality, the type of market you target (fresh or processed) and supply and demand for your product.



Contacts and futher reading

Vegetable Agronomy

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NSW Department of Primary Industries
Yanco Agricultural Institute
YANCO NSW 2703

Vegetable Entomology

Technical Specialist Vegetables, Yanco

Vegetable Pathology

Research Pathologist Vegetables, Yanco

Further Reading

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5.3 Organic production of processing tomatoes

Introduction

Processing tomatoes differ from those grown for the fresh market. They tend to be thicker skinned and less acidic and have a lower water content and higher pulp content than fresh market types. They are grown un-staked on beds, often in double rows.

Large-scale monoculture production is a feature of conventional processing tomato operations.

Processing tomatoes are mechanically harvested and transported in bulk carriers to processors.



Organic production on the same scale is unlikely to be successful. However, careful field layout involving intercropping with other species or staggering plantings could increase the scale of operations and extend the harvest period.

Organic producers sell directly to wholesalers or processors or carry out some form of on-farm value-adding.

A large range of processed organic tomato products is produced. This includes pasta sauces, salsas, juices, ketchup, baby food, tinned whole and pieces, dried tomatoes and pastes.

Most of the organic processed tomato products currently on the Australian market are imported.

Rotation design

Tomatoes belong to the botanical family *Solanaceae.* Other members



Tomatoes belong to the botanical family Solanaceae

in the family include eggplant, capsicum and potatoes. Rotation design should avoid preceding tomatoes with other solanaceous species, thus reducing the potential for pest, disease and weed carryover. Rotation to non-solanaceous crops for three years is usually recommended to avoid pest problems common to this group of vegetables.

If an intensive market garden regime is practised or where long rotations are impractical, green manuring should be implemented. This practice will help to increase organic matter, biological activity and nutrient reserves prior to cropping and will also favour the suppression of soil-borne diseases. A green manure grown prior to planting should be well incorporated, with minimal crop residue apparent before planting the tomatoes.

Ideally, a green manure should consist of a range of deep and shallow rooted herb, legume and grass species. Sod crops preceding tomatoes—such as grass pasture and small grains crops—may result in heavy cutworm and/or wireworm damage to tomatoes.

Some producers practice long rotations where the tomato crop is preceded by a 3-year legume-based pasture or lucerne crop. In this instance, nitrogen requirements of the tomato crop should be met by ploughing down the pasture or lucerne well before planting, allowing adequate time for decomposition and ground preparation.

Tomatoes have a relatively shallow root system, extending down to around 30cm. It may be good practice to follow the rotation with a deeper-rooted species able to extract nutrients from deeper in the soil profile.

Paddock layout could include tomatoes inter-planted with insectary species. This practice involves

Inter-planting the main crop with species they are more attractive to pests than the main crop (also known as trap cropping) or that provides a food source (such as nectar) for beneficial species, which migrate into the main crop and predate on pests.

Trials in cotton have shown pest control benefits from inter-planting cotton with 20m x 1m rows of lucerne (totalling 4% of the area planted). Research investigating layout of chickpeas as a trap crop for *Heliothis armigera* in cotton has shown that blocks of chickpeas are more effective than strips or patches.

More research needs to be undertaken on suitable species for inter-planting in tomatoes and on the ratio of main crop to insectary crop for optimum benefit.

Variety selection

Choice of variety will depend on market demand, regional adaptability, disease resistance and the end use of the product. For example, the Roma type is the market preference for drying, while tomato paste processors require a product with high total soluble solids (TSS).

The crux of successful organic production of processing tomatoes can often be resistance or tolerance to disease. Some diseases may be more of a problem than others in your district, so you should ensure that the variety you choose has been bred for tolerance or resistance to these diseases. Seed supply companies will be able to provide this information.

Crop nutrition

Nutritional requirements of processing tomatoes are met organically by a range of practices such as green manuring, cover crops, livestock manures and composts, lime, mineral rock dusts, commercial organic fertilisers and foliar sprays.

Many organic sources of nutrients may take a number of seasons to become fully available, so soils should be assessed for their nutrient status a few seasons before planting the tomatoes. This is particularly the case with rock phosphate and mineral dusts. These can be added to composts.



Organic fertiliser

Tomatoes prefer a soil with a pH of 6.0 – 6.8. Soil pH below this can be adjusted by adding natural lime to green manures or pastures before they are incorporated. If magnesium is found to be lacking, dolomitic lime should be applied.

Tomatoes require moderate to high levels of phosphorus and potassium. Advanced applications of rock phosphate should be made based on soil test results. The availability of rock phosphate in less acidic soils (>5.5 pH) in low rainfall areas can be improved by applying the colloidal form. The addition of elemental sulfur has also been shown to improve solubility; although this will also cause a moderate increase in soil acidity.

The crop's potassium and sulfur requirements can be met with applications of mined sulfate potash. Compost and seaweed fertilisers are other organic sources of potassium.

Ground preparation and planting

Primary cultivation should aim to turn under green manures or cover crops well before planting to allow for adequate decomposition.

Initially, soils should be worked deeply to ensure adequate soil depth for bed forming. Deep-ripping is advised if beds are being formed for the first time. If soils are poorly drained, adding naturally mined gypsum prior to ripping may be beneficial.

Follow-up cultivations should be slow and shallow, and should avoid bringing subsoil to the surface. This will minimise the germination of weeds.

The aim should be to produce straight, evenly spaced beds to facilitate cultural (particularly weed management) and harvest operations. Bed width will most likely be determined by machinery wheel spacing.

Once formed, beds should be irrigated if rainfall is insufficient prior to sowing to stimulate weed emergence. A final slow and shallow cultivation to remove weed seedlings usually then precedes planting.

Transplants are the most common method of planting. Transplants are preferred over seeds as they have a competitive advantage over weeds. Transplants should be raised organically. This is a requirement of the National Standard for Organic and Bio-Dynamic Produce.

If organic seedlings are not available you must provide evidence to your certifier that you have made every effort to source organic material. These should be pre-ordered (if



Selecting crops to include in a green manure it is important to use a range of root systems that can explore, work and enrich the soil. Shown here, from left, are oats, faba beans and fodder rape. Source: NSW Department of Primary Industries

not growing your own) at least 6 months prior to planting to ensure that suppliers can supply the variety and quantities you require.

Check transplants upon arrival to ensure they are pest and disease free. If pests or disease are present, treat with an organically acceptable pesticide prior to planting.

Transplants should be hardened-off after delivery and pre-watered prior to planting.

Transplants are generally planted by machine, although hand planting may be considered for smaller areas.

To avoid stimulating weed germination, aim for minimum soil disturbance during planting.

Plants should be placed 40cm apart in straight, evenly spaced double rows. Tomatoes should be watered-in as soon as possible after planting.

Planting in double rows makes efficient use of soil nutrients and encourages rapid coverage of the bed surface thus providing competition (shade, moisture and nutrients) against potential weed invasion. However, weed control can be more difficult between the two rows.

Alternatively, the tomatoes could be planted in single rows and undersown with a leguminous green manure crop. Suitable species could include dwarf red and white clover.

Undersowing is best done 4 weeks after planting tomatoes to ensure they are well established.

You will need to flame or cultivate any weeds that emerge in this intervening period. The clover should be sown in a weed-free seedbed.

Careful water and nutrient management will be needed to ensure competition between the cover crop and tomatoes does not occur.

Weed management

Weed management begins well before planting. If planting in a previously uncropped field, you should select one that is relatively weed-free. This is particularly important with difficult to manage weeds such as nightshade or weeds with persistent seed banks such as Bathurst burr.

If the tomatoes are part of an ongoing rotation, weed 'cleaning' crops such as short season vegetables or green manures should precede the tomato crop.

Weeds in areas bordering the field should be controlled, particularly if they are hosts for thrips or aphids as these may transmit diseases to the crop.

Irrigation as a weed control method

Beds should be pre-irrigated or have received rainfall prior to planting to stimulate weed germination. Germinating weeds are then controlled by shallow cultivation or flaming prior to planting.

Sub-surface drip irrigation can minimise weed competition. The drip line should be buried at, or just below, rooting depth.

You may need to compromise slightly with the depth as the drip line will remain in the soil for a number of seasons and crops following tomatoes in the rotation may have a different root depth.

Soil type will also dictate the depth at which the drip line should be laid. Crop type and soil type will also dictate the distance between in-line emitters in the drip line. If unsure, you should seek advice from the drip line supplier or a NSW Department of Primary Industries Irrigation Officer. NOTE: Some drip line is impregnated with herbicide, so be sure to specify when purchasing that this is not required.

Post-planting weed control

The critical period for weed management occurs during crop establishment and until the tomato crop canopy closes over the bed. Following planting, emerging weeds can be flamed or interrow cultivated.

Weeds emerging within the plant row may require hand removal (chipping) at least until the crop canopy closes.

Once the crop canopy closes over the bed, little—if any—weed management is usually required. Weeds in the furrows between beds may be mechanically cultivated or flamed.

The application of surface mulch may also be considered to suppress weeds and to conserve moisture. Non-synthetic woven or processed materials or organic mulches such as straw, hay, sawdust and rice hulls are suitable. Equipment is available to mechanically lay some commercial mulch. These should be laid prior to transplanting.

Organic mulches should be maintained in a layer 10cm or deeper, and are generally applied after planting so not to interfere with equipment. If surface mulch is applied, drip irrigation can be placed under the mulch on the bed surface.

Insect pest management

Effective pest management can only be achieved through monitoring and correct identification of the pest and predatory species. An understanding of the pest's (and predator's) lifecycle will help you to plan and design an integrated pest management strategy.

Monitoring for the presence of pests and predators should start before planting—in surrounding fields, on weeds and in the soil. The presence of pests that live in the soil (such as wireworms) can

be determined by soil sampling. Sticky traps, baits and light traps located around the field will help to monitor the presence of flying insects. Crop monitoring should be done at least weekly.

Beneficial insects are very susceptible to insecticides, so care must be taken to reduce drift from neighbouring properties. Some organic farmers plant windbreaks or arrange with their neighbours to sow crop buffers such as sorghum along the boundary. *Casuarina* spp. is very effective at reducing spray drift by trapping spray droplets.

Windbreaks also add to the biodiversity of the farm by providing shelter for smaller birds and other potential pest predators.

Major insect pests of tomatoes

Caterpillars

Helicoverpa spp (Heliothis). *Heliothis punctigera*, and *H. armigera* are the two most common species that damage tomatoes.

While *Heliothis* larva will feed on buds and flowers of tomato plants and may also bore into the stems, it prefers fruit. Fruits that are damaged when young are most likely to rot before harvest.

Monitoring for *Heliothis*

All processing tomato producers monitor crops on a twice-weekly basis from planting until about two weeks before harvest. Regular monitoring for pest presence will let you know if the beneficial insects are present and if they are keeping *Heliothis* at a satisfactory level of control. Pheromone and light traps are used to monitor moth numbers, species and flight patterns.

Monitoring pest/predator build-up involves collecting random leaf samples to determine the level of *Heliothis* eggs present. The eggs are then collected and inspected 4–6 days later to determine the level of parasitism from wasps such as Trichogramma or Telenomis. If the eggs turn black, they have been parasitised by the wasp. This enables you to determine if an organically acceptable spray is required to further reduce pest numbers. The threshold for spraying *Heliothis* in tomatoes is five viable eggs on 30 leaves or 2 larvae on 30 leaves. See Table 1 for beneficial insect and spider ratings as reported by the Department of Primary Industries, Queensland.[1]

Biological control

Mass-reared beneficial insects including *Trichogramma* wasps are available for biological control of *Heliothis*. These wasps are egg parasites of *Heliothis*. Commercially reared *Heliothis* eggs parasitised by *Trichogramma pretiosum* may be released to control *Heliothis* and loopers, although this is an expensive operation, costing around $100 per ha.

Eggs can be released in a water solution through a backpack at a rate of 8 ha / hour or over larger areas with a specially built machine, or on egg cards that are placed throughout the field. The most important consideration with *Trichogramma* release is timing. Farmers have found it is normally necessary to make two releases approximately 5–7 days apart. Monitoring is essential to determine the best time for release.

Cultural controls

It is possible to reduce the risk of *Heliothis* damage through a number of cultural practices.

Plant early. Early season crops (harvest late January / early March) are generally less prone to damage from Heliothis. Avoid planting late season crops in NSW.

Cultivar selection. Different tomato varieties may be able to tolerate different levels of insect damage. More research is required in this area.

Crop sanitation. Thoroughly cultivating the field after harvest will destroy pupation chambers (this known as 'pupae busting'). This will reduce the population of the next generation of *Heliothis*.

Insectaries and strip cropping

Strip or trap cropping is 'growing two or more crops simultaneously in different strips, wide enough to permit independent cultivation, but narrow enough for the crops to interact agronomically' (Francis,



Effective biological control requires an effective system design. A Heliothis *caterpillar is parasitised by a predatory shield bug in a pigeon pea trap crop.* Photo: R. Neeson

[1] *Deuter, P, et. al. (2000),* Heliothis *in Sweet Corn, Queensland Horticulture Institute, Gatton Research Station.*

C.A., *Multiple cropping systems*, 1986, MacMillan). Strip crops, or insectaries, can be the breeding grounds for beneficial insects that migrate, are forced (for example, by cutting) or transferred (by D-Vac™ suction collection) to nearby commercial crops.

In trials conducted at NSW Department of Primary Industries Yanco Agricultural Institute's organic demonstration site, pigeon pea has been shown to be a very effective trap crop for *Heliothis* when planted in soybeans.

Sweet corn has also shown some effectiveness as a trap crop. The egg-laying moths prefer corn to beans, tomatoes and other crops, so borders or strips of corn planted around or within the crop may reduce *Heliothis armigera* densities on the less-preferred crops. This approach is likely to only be effective if the corn is silking at the same time as the tomatoes, or other crops are setting pods or fruit. Staggered plantings would be required to ensure silking is continuous.

Organically acceptable pesticides

These include naturally occurring bacterial and viral insecticides. They can provide significant control of *Heliothis* in tomatoes if applications are well timed and frequent. Note: All products must be registered for their designated use. Minor use 'off-label' permits may be obtained by contacting the Australian Pesticide and Veterinary Medicine Authority.

Table 1. Beneficial insect and spider ratings (sweet corn)

Common name	Scientific name	Beneficial rating*
Wasps and ants:		
Trichogramma	**Hymenoptera:**	+++++
Black ants	*Trichogrammatidae*	+++++
Microplitis	*Iridomyrmex* sp.	++++
Telinomus	*Microplitus demolitor*	+++
Bugs:	*Telinominae*	+++
Black mirid	**Hemiptera:**	++++
Pirate bug	*Tytthus chinenis*	+++++
Apple dimpling bug	*Orius* sp.	+++++
Brown smudge bug	*Campylomma liebknechti*	++
Bigeyed bug	*Deraeocoris signatus*	++
Damsel bug	*Geocoris lubra*	+
Spiders:	*Nabis kinbergii*	+
Foliage dwellers (e.g., jumping spider)	**Araneae:**	+++
Soil dwellers(e.g., wolf spider)	*Salticidae*	++++
Web builders (e.g., orb weaver)	*Lycosidae*	+++
Beetles:	*Araneidae*	++
Ladybirds	**Coleoptera:**	+++
Carab beetle	*Coccinellidae*	+++
Red and blue beetle	*Carabidae*	++
Green soldier beetle	*Dicranolaius bellilus*	++
Lacewings:	*Chauliognathus pulchellus*	+
Green Lacewing	**Neuroptera:**	++
Brown Lacewing	*Mallada* sp.	++
Flies:	*Micromus tasmaniae*	++
Tachinid flies	**Diptera:**	++
Hover flies	Tachinidae	++
	Syrphidae	+

** Level of pest management in sweet corn = Low (+); Moderate (+++); High (+++++).*

The sap-suckers

Aphids, leafhoppers and thrips are sap-suckers that reduce crop vigour, fruit quality and yield. Some may act as vectors, or carriers, of viral diseases in tomatoes and other plants.

Thrips

Thrips are very tiny, slender insects that feed primarily in flowers and developing fruit. Thrips transmit the tomato spotted wilt virus (TSWV), causing tomato spotted wilt. Not all species of thrips are capable of transmitting the virus. The onion thrips (*Thrips tabaci*) is the most common vector of TSWV in Australia.

The thrips acquire the virus as they feed on tomatoes and other host plants, including weeds. Thrips are most likely to migrate to tomatoes when plants they have been feeding on have matured or dried out.

A large number of weeds and ornamentals (particularly perennials) are known to host thrips, and while removal of host weeds or those known to be susceptible to spotted wilt will reduce the risk of disease transmission, this may not be a practical solution.

Anecdotal evidence suggests basil interplanted in tomatoes may help to repel thrips.

When monitoring for thrips, sampling should be done at the same time as *Heliothis* sampling. Select one tomato flower from each of the plants sampled (5 plants per location in the field). The flowers are then placed in jar with alcohol and after a few minutes the thrips will sink to bottom of the jar where they can be counted. Tapping flowers into the palm of the hand is another quicker method.

An organic spray is recommended if an average of one thrips per flower is found (5 thrips in a jar with 5 flowers). Soap, natural pyrethrum and horticultural mineral oils can be used successfully.

The common brown leafhopper (*Orosius arentatus*)

This is a brown speckled insect about 3mm long that is responsible for the spread of the mycoplasmic disease Big Bud.

Host weeds in and around the crop should be destroyed. High tomato plant populations can reduce losses due to the disease within the crop.

Aphids

These feed on the underside of leaves, causing curling and reduced growth potential. The feeding of large numbers of aphids results in excretion of honeydew that supports the growth of secondary fungal diseases. Aphids may also act as vectors of certain virus diseases of tomato. Virus transmission has been observed when lucerne is interplanted to attract beneficials.

Research has shown that reflective polyethylene mulch placed on beds before transplanting significantly reduces the rate of colonisation by winged aphids and whiteflies, and can delay the build-up of damaging numbers of aphids by 4 to 6 weeks.

Control of aphids

Common natural predators of aphids are lady beetles and their larvae, lacewing larvae, and syrphid fly larvae. Aphid parasitoids, *Aphidius* spp, can occur naturally in the field, but often only when aphids are in large numbers. *Aphidius* spp are commercially reared in New Zealand, while green lacewings *Mallada signata* are commercially available in Australia.

Organically acceptable pesticides to control aphids are sprays of insecticidal soap or natural pyrethrum. Pyrethrum is harmful to beneficials so treatment should aim to avoid their peak activity, but still contact aphids.



*The Green Vegetable Bug (***Nezara viridula***) is one of the more difficult pests to organically control.*
Photo: R. Neeson

Organic farmers have reported good control of aphids with spray applications of garlic oil, when it is combined with mineral oil and pure soap.

Green vegetable bug (*Nezara viridula*)

The green vegetable bug (*Nezara viridula*), or GVB, also damages fruit through the sucking and piercing feeding action, although there are no reports of disease transmission through this activity. Tomato fruit that is attacked develops mottled areas.

Organic control of GVB is difficult. Release of predatory wasps and natural predation are the common control methods relied upon by organic producers. A parasitoid wasp (*Trissolcus* spp.) and parasitic fly (*Trichopoda* spp.) are two predators of GVB.

The CSIRO has conducted trials aimed at establishing the South American parasitoid, *Trichopoda giacomellii*, at sites in south-eastern QLD and northern NSW. Results indicate that *T. giacomellii* has successfully established in these regions and is now impacting on the abundance of GVB at sites in northern NSW. Ants are also known to be effective predators of GVB.

Crop nutrition. Some organic farmers apply foliar sprays when the plant is under insect attack, believing this improves plant health and renders the crop less attractive to pests.

Two of the most common foliar sprays are kelp and fish emulsion.

Organically acceptable insecticides. Natural pyrethrum is a pesticide used by organic farmers to limit GVB damage. However, in trials conducted at Yanco organic demonstration site, pyrethrum did not give a satisfactory level of control against GVB.

Trap cropping. It may be possible to plant species that are more attractive than tomatoes to GVB.

This attracts the GVB away from the crop, where they can be destroyed eg by cultivation, rolling or mulching. Suitable crops include sunflowers, soybeans and *Amaranthus*.

Cultural control. Some of the crops that are effective trap crops can also host GVB, for example, *Amaranthus*. You will need to weigh up whether your aim is to use these plants in a trap situation or try to control them in the area instead.

If you do not wish to use trap cropping, then plants and weeds in areas immediately surrounding the tomato crop that are known to host GVB should be controlled.

Weeds known to support development of GVB include castor oil, yellow-vine (caltrop), privet and *Amaranthus*. GVB has also been observed on silver leaf nightshade.

Mite pests

Two-spotted mite (*Tetranychus urticae*) and tomato russet mite (*Aculops lycopersici*) feed on the underside of leaves. Tomato russet mite also feed on the stems and on fruit. Damage is usually greater in hot, dry weather. Both mites are extremely small, best seen with a hand lens or magnifying glass.

Biological control. The predatory mites, *Phytoseiulus persimilis* and *Typhlodromus occidentalis*, and the fungus gnat, *Hypoaspis* spp are commercially available to control two-spotted mite. A small, shiny black ladybird (*Stethorus* spp.), often occurs naturally in the field and is also an effective predator.

Predators that are commercially reared and released in the crop will require a non-crop plant on which to overwinter once the commercial crop is harvested. Otherwise, annual releases will be required. Windbreaks containing a variety of species and weedy borders (that don't host pests or diseases) act as suitable overwintering sites.

Monitoring of pest and predator populations is essential to track their movement into the crop, their numbers and hence effectiveness.

Chemical control. Wettable sulfur and sulfur dusts are organically acceptable compounds are available that will control mite pests. Horticultural mineral oils can also be used successfully at rates between 0.5 – 1.0% volume of oil / vol water. Sprays should not be applied when temperatures are above 35°C and caution should be taken to avoid spraying when predators are most active.

(Note that Japanese organic standards have recently been amended to disallow use of these, so producers intending to supply this market need to be aware of this when considering this type of control).

Diseases and nutritional disorders

Organic producers should aim to select tomato varieties that are bred for resistance to disease.

Long rotations with non-related crops and improving soil biological activity through incorporation of green manures and compost will have a positive impact on reducing the incidence of soil borne diseases. Crop sanitation, by removal and composting or ploughing under of crop residues, will help to prevent disease carryover.

Compost teas could prove beneficial in control of certain bacterial and fungal diseases.

Viral and mycoplasmic diseases

Big bud

Big bud is a mycoplasmic disease that may not develop until six weeks after infection by the brown leaf-hopper (*Orosius argentatus*). It is more common in dry inland regions from October, particularly after hot weather forces leafhoppers from weeds and on to crops.

Symptoms appear as a thickening of stems, and a proliferation of small stiff shoots with short internodes. Roots may develop high on the stem and splitting may occur. Flower buds are greatly enlarged and do not develop properly.

Control. Weeds in and around the crop that host the brown leaf-hopper should be destroyed. Increasing tomato plant populations can help to reduce losses.

Spotted wilt

Spotted wilt is a viral disease that can cause heavy losses in spring and early summer crops. The disease is spread by the onion thrips (*Thrips tabaci*), a small yellowish brown / grey flying insect about 1mm long, and by Western Flower Thrips (*Frankliniella occidentalis*). It breeds on weeds and migrates on to tomatoes as weeds dry out. Dandelion, lamb's tongue, nightshade and thornapple are favoured weed hosts. Many ornamental plants also host spotted wilt.

Symptoms first appear 7 to 20 days after infection. Small areas of bronzing appear on the upper side of young leaves in top growth, and on older leaves as bronze spots or rings between the veins. As the disease develops the spots blacken and shrivel.

Affected fruit show irregular or circular blotches as they ripen, often shrivelling and falling off.

Control. Weeds and ornamentals that may host thrips near the crop should be destroyed. Tomatoes should not be planted near flower crops.

Increasing tomato plant populations can help to reduce losses. Soap, natural pyrethrum and horticultural mineral oils can be used successfully to control thrips.

Bacterial diseases

Bacterial diseases commonly affecting processing tomatoes include bacterial canker (*Corynebacterium michiganense*), bacterial speck (*Pseudomonas syringae* pv. *tomato*) and bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*).

Sources of infection include seeds, contaminated soil (can survive in soil for up to 3 years and, in the case of bacterial speck, on plant debris for 30 weeks), and weeds (particularly blackberry nightshade, *Solanum nigrum* and thornapples, *Datura* spp.).

Control. A 4–5 year rotation between tomato crops is desirable. Seeds saved from healthy plants should be planted. If the disease status of seed is unknown it should be treated in hot water.

Host weeds in and around the crop should be destroyed. Sanitation should involve removing and burning diseased plants as they appear.

Hands and tools should be washed in warm soapy water after touching diseased plants. Overhead irrigation should be avoided.

Crop refuse should be deeply buried or removed for composting.

At the time of writing, use of copper hydroxide is an organically acceptable chemical control method. However, the use of copper as an allowed organic treatment for disease is currently under review.

The National Standard for Organic and Biodynamic Produce (2003) states that the annual application of copper should not exceed 8 kg/ha/annum and that producers should have a staged reduction strategy in place.

Producers should check for any changes to the National Standard by looking on the web site www.aqis.gov.au/organic.

Fungal diseases

Fungal diseases commonly affecting processing tomatoes include anthracnose (*Colletotrichum* spp.), and *Phytophthora* spp.

Spread of anthracnose is favoured by warm, humid conditions with temperatures above 26°C and relative humidity above 93%. *Phytophthora* commonly occurs where extremes in soil moisture occur and where drainage is poor.

Control. Anthracnose is controlled by hot water treatment of seeds, crop rotation and sanitation measures. Anthracnose is principally a disease of ripening fruit, so harvesting mature green fruit can reduce incidence.

Copper hydroxide sprays may (at the time of writing) be used when fruit begins to ripen. However, producers should check before use to ensure this is still permitted.

Phytophthora incidence can be minimised by good irrigation management and adequate drainage.

Maintaining high organic matter and biological activity in the soil will also assist in control of *Phytopthera*.

Nutritional Disorders

Blossom End Rot

Blossom-end rot appears as brown to black spots on the underside (blossom-end) of the fruit of tomatoes. As the fruit grows, half or more of the fruit may be affected — the fruits ripen earlier and may be prone to secondary infections.

Causes. This is primarily a nutritional disorder is caused by a deficiency in calcium, a water-soluble element. Any factors affecting water and calcium availability, or movement, into the plant will therefore contribute to the problem.

Environmental and cultural factors that contribute to the occurrence of blossom end rot include:

- poorly drained soil
- improper soil preparation and planting
- inadequate or excessive watering
- soil pH levels below 5.5
- inadequate calcium in the soil
- applying too much nitrogen
- excessive root disturbance
- use of plastic mulch instead of an organic mulch, high soil and air temperatures and low humidity.

Control. Contrary to past belief the direct application of calcium as a spray is ineffective.

A soil test should be conducted to help determine nutrient levels. Excess levels of ammonium, magnesium, potassium and sodium have been reported to reduce the availability of calcium.

The addition of limestone, gypsum or dolomite to the soil well before transplanting is recommended to overcome the soil calcium deficiency. Liming is recommended in areas with low pH (below 5.5) soils.

Maintaining the proper balance of potassium, phosphorus and other soil nutrients and avoiding excessive growth due to over-fertilisation with nitrogen is recommended.

Having a uniform and adequate soil moisture content is critical to preventing blossom-end rot. Irrigation scheduling with the aid of soil moisture probes and mulching can help to maintain optimum soil moisture for plant growth.

Harvesting and marketing

Conventional processing tomatoes are harvested mechanically to supply large processors. Vines are lifted from the field, the fruit removed mechanically and then conveyed along a sorting platform, where it is graded by field workers.

Fruit is graded according to whether it is rotten or badly blemished (rejects), mature green and red ripe. The degree of acceptable blemish will depend on your end market. For example, a higher degree of blemish will be acceptable for fruit that is to be pulped than for whole peel or dried tomato products. Some tomato growers invite hand picking for the local market prior to machine harvesting.

Markets

A large range of processed organic tomato products is currently produced. These include pasta sauces, salsa, juices, ketchup, baby food, tinned whole and pieces, dried and pastes. Most of these lines are currently imported into Australia.

Contracts for processing tomatoes are difficult to obtain unless you are an established producer. Contracts are issued before the season begins.

Organic processed tomatoes are a niche product, not yet being sourced in Australia by the larger tomato processors. However, there does appear to be potential for import replacement of processed tomato products.

Heinz Watties currently contracts New Zealand organic producers to produce processing tomatoes for their organic baby food lines. Cedenco Foods Ltd, New Zealand, is developing a number of processed organic vegetable lines. Australia has a climate more suitable for processing tomato production, so potential exists for Australian organic producers to become the preferred supplier should reliable supplies become available. Growers should investigate these opportunities.

Smaller producers could consider on-farm value-adding or supplying unprocessed product to farmers' markets, health food and restaurant outlets. Consumers often prefer the egg or Roma type processing variety. The Sydney based wholesaler and exporter, Eco Farms, has indicated interest in receiving processing tomatoes to supply smaller clients.

If processing is carried out on-farm you will need to have these operations inspected by your certifier. Your processing operation must also comply with State and Territory health regulations. The development and implementation of a Hazard Analysis Critical Control Point (HACCP) plan will help you to achieve compliance with organic standards and health regulations.

Economics

The economics of organic processing tomato production will largely depend on the market you are targeting. On-farm value-added products will return more than unprocessed tomatoes sold to a processor. However, the labour and infrastructure requirements for on-farm value-adding will be significantly greater. So, returns will largely depend on how much effort, time and initial resources you are prepared to outlay.

Returns will also depend on costs of inputs (labour, fertiliser), yield, quality, the type of market you target (fresh or processed) and supply and demand for your product.



Organic whole peeled canned tomatoes – one of the processed tomato product opportunities available to Australian organic producers.. Source: <http://www.goodnessdirect.co.uk/detail/340456b.jpg>

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Further reading

Organic Industry Export Consultative Committee (OIECC) 2003, The National Standard for Organic and Bio-Dynamic Produce, c/o AQIS. See the website www.aqis.gov.au/organic.

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6. Post-harvest management and marketing

Post-harvest management must ensure that the quality and the organic integrity of the product are retained—from paddock to plate.

Vegetable producers must ensure that harvested product does not become contaminated after it leaves the paddock. Harvest bins and transport—particularly if provided by contractors—need to be thoroughly cleaned to remove potential contaminants. Since few chemicals for prolonging post-harvest storage of the product are permitted, optimum hygiene and storage conditions must be provided. Certifiers will require that freight transporters be inspected or that information about post-harvest storage and disinfestation procedures be provided. Storage and packaging facilities will probably also have to be inspected. Any processing of organic vegetables must be certified. Certification is sometimes a deterrent to processors, particularly if only a small quantity of organic produce is to be processed. Producers could consider forming processing cooperatives.



Organic farmers selling their produce at Lismore's Rainbow Region Farmers' Market. Farmers' markets offer producers a personal approach to selling their produce. Photo: R. Lines-Kelly

6.1 Quality assurance

Quality assurance of products entering the marketplace is becoming increasingly important. Consumers of agricultural produce need to be assured that the products they buy meet their expectations for safe and wholesome food. Large supermarket chains and export markets are starting to demand that goods be produced in conjunction with a system that offers full traceability. As Australia develops new export markets, it must be remembered that many of the countries that import our produce now enforce quality specifications more rigidly than ever before, and failure to meet specifications may see the loss of these markets. This is just as relevant for organic produce as it is for conventional produce.

Consumers demand quality—particularly for fresh fruit and vegetables—and, since most people 'buy with their eyes', farmers should be rigorous throughout the grading process. Supplying blemished or damaged produce is not acceptable. Poor quality reflects on the industry as a whole. Damaged (provided it is not breaking down) or blemished produce need not be discarded, however. Consider value-adding to second-grade product by processing it into purees or juices or packing it as pieces.

Organic producers wishing to receive training in quality management can do an accredited quality management course. Two such courses are the regularly conducted National Organic Auditor Training workshops and the Independent Organic Inspector Association Organic Training workshops.

Quality assurance of organic products is crucial to ensure that there is no contamination by products excluded from the standard. Among the potential risks are pesticide and microbial contamination and contamination with genetically modified or conventional product. An important aim of any quality assurance program is to eliminate problems before they occur and, if possible, to reduce reliance on end-point inspection (quality control).

6.1.2 Quality

[This section is reproduced from *Marketing Organic and Biodynamic Products: conference proceedings* (NSW Agriculture 1997). Joseph Ekman, Extension Horticulturist, Quality Assurance, NSW Department of Primary Industries, contributed what follows.]

Quality is no accident. Climatic conditions may vary from season to season but product quality is essentially the end result of investment of money, time and labour. Quality can only be achieved consistently and efficiently through managing the activities and inputs that affect quality from the field through to the customer. Consistently achieving the 'right result' requires planing and implementing a quality system. 'Quality assurance' can be defined as 'all the planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality'. Quality assurance requires the planning and implementation of a quality management system.

Every producer has some kind of informal quality system in place. More often than not this information is stored 'in the manager's head'. A formal, auditable quality system requires production and post-harvest operations to be planned, documented, implemented, verified and certified to a recognised standard. Management to satisfy a standard is familiar territory for organic and biodynamic producers certified to the National Standard for Organic and Biodynamic Produce or respective group standards. However, there are numerous other quality system standards in operation, all of which are based on similar principles. Figure 6.1 illustrates the principles generic to most quality systems.

Why develop a quality system?

Agriculture in Australia has been changing rapidly in recent years and the pace of change continues to accelerate. These changes include:

- changes in consumer preferences for products
- increased production and geographical spread of many crops
- government retreat from enforcing product quality standards and the push to market self-determination on quality
- increased competition from imports.

These forces are changing the way Australian producers market their crop. Many of the problems facing producers can be tracked down to a failure to research and understand what their customers really wanted. Australia has earned a poor reputation in overseas markets because of variations in product quality, poor or patchy market service history, and a poor understanding of market-specific requirements.

Changes on the domestic marketing scene are also putting greater pressure on producers to supply products of consistent quality. Chain stores (supermarkets) continue to capture market share in fresh produce retailing, and they prefer to supply of long lines of consistent quality product. As their market share grows, chain stores are demanding rigid standards for the products they buy. They want to know that the products they sell meet their consumers' expectations, in order to gain consumer loyalty and repeat purchases.

Purchasing long lines of consistent quality products can also simplify their handling and distribution logistics, reduce wastage and reduce operating costs.

Rising production costs are also putting pressure on growers to improve their quality consistency to remain competitive. The threat of an industry collapse from oversupply is forcing producers in many industries to look overseas for new markets. There is no doubt that successful penetration of export markets will require close attention to the needs and expectations of customers.

The major challenge for the future of Australian producers is being able to supply consistent quality products and service to markets.



Organic produce in a Woolworths supermarket

Forces driving change in agricultural industries

Group marketing:

- strength in group marketing
- demand for long lines and continuous supply
- brand establishment—product differentiation

Retailing

- consumers and health authorities demanding safe, quality foods
- less consumer time to shop around—one-stop shopping
- direct sourcing of produce from farms—contract growing/alliances
- use of product specifications

International trade

- decreasing tariff and trade barriers (WTO)
- opening of new markets
- competition (domestic and international) and declining global market share

Business environment

- need for profitability/efficiency gains
- increases in production and market saturation
- *quality* replacing *price* as the competitive advantage
- government deregulation of industries



Figure 6.1 The quality system cycle. Source: Adpated from Ekman 1997

Quality costs

Quality costs! However, the costs of quality and getting it right must be assessed relative to the costs of quality failure.

All quality systems are a balance between the cost of getting it right and quality failure. The three categories of quality costs are:

- prevention costs—the costs of preventing quality failure, including the planning and maintenance of a quality management system and certification
- appraisal costs—the quality control costs of ongoing monitoring of products and services such as product testing and inspection from production to marketing
- failure costs—the cost of final products or services that do not satisfy customer requirements. Failures detected before the product reaches the consumer are termed 'internal failure costs'. Failures that result in dissatisfied customers are 'external failure costs'.

Quality costing provides a basis to assess the value of a quality system to an organisation and to assist management to identify opportunities for efficiency gains and cost reductions.

The key to improving quality and profitability is failure prevention.

A quality management system increases the prevention costs in a business but, when the system is implemented effectively, the cost is more than compensated for by reduced failure costs, operational efficiency gains and increased competitive potential in the market.

Quality system benefits

The following are some of the main benefits of failure prevention achieved through quality management:

- improvement in product consistency
- improved competitiveness and ability to adjust to market change
- enhanced reputation in the market
- reduction in liability risks
- reduced wastage and rework of products
- process efficiency gains
- decrease in labour and material costs
- improved employee involvement and morale
- improved return on investment.

Quality systems are a tool businesses can use to provide the assurance customers want. By focusing on managing activities that affect safety and quality, the quality system helps organise the way things are done and provides organisational confidence in the ability to consistently provide the goods and services customers require.

Elements of quality management systems

Quality plans. A quality plan (manual) sets out the policies, resources, practices and responsibilities for the business to meet its customers' requirements for products and service. Appropriate quality system plans can make the difference between an easy-to-use system and one that sits on the shelf.

Product specifications. Specifications are a tool for improving customer–supplier relationships. The important feature of specifications is that they objectively define the requirements of a product, thereby avoiding confusion. They also provide a means of objectively monitoring performance in meeting the specifications.

Management and staff. Improvements can be achieved only if management and staff are working toward similar goals. A successful business—with a reputation for quality—provides better job security and job satisfaction for employees. When the whole organisation runs smoothly and everyone is involved the success helps build confidence and teamwork. Management must ensure staff have a clear understanding of what is required of them. Many managers often underestimate the contribution staff can make to the business when given the opportunity. Being part of the quality system from the beginning lowers staff resistance to any improvements or changes to be made and often improves morale.

Customers and suppliers. Customers and suppliers are other links in the production, delivery and marketing 'supply chain'. It is important that suppliers know what their customers want if they are to reliably supply products of the quality expected. Often it is the supplier who must ask the customers what they require and seek feedback on how well the requirements are being met. Most unhappy customers don't complain—they simply don't come back. In the same way that a business needs to understand what its customers' requirements are, the business must also define the qualities of products it uses and

communicate its expectations of quality to its suppliers via specifications.

Documentation. Documentation can help make decisions, assist in running the business, and help staff do their job. More paperwork does not, however, mean better systems. One of the aims of a quality system is to reduce wastage, so it is important not to create excessive paperwork. People drive a quality system—not paperwork. One of the main functions of documentation is to help improve communication. This overcomes problems of poor verbal communication and memory failures. Documents are valuable tools in that they record what has to be done and what has been done.

Quality system standards

There are a number of quality, food safety and environmental management systems that affect Australian agricultural industries. Key established and emerging standards and codes of practice include:

- ISO 9000:2000 and ISO14001
- Safe Quality Food 2000 and 1000
- Woolworths Vendor Quality Management Standard
- CATTLEcare/FlockCare, Freshcare, Graincare, and so on—HACCP-based codes of practice
- EUREPGAP—for suppliers to European retailers
- many other industry-specific standards and approved supplier programs.

The systems implemented by a business will need to satisfy the requirements of its customers. Businesses need to expand their definition of 'satisfied customers' to include regulatory authorities in regard to food safety and phytosanitary requirements. Food Standards Australia New Zealand (previously known as the Australian and New Zealand Food Authority) is implementing new national food standards in the food service and processing sectors. It is also developing a framework for the establishment of 'Primary Production Standards'.



Organic bread found in Woolworths supermarkets.

HACCP

Food safety plans are conventionally developed in food industries using the HACCP technique. HACCP stands for the Hazard Analysis and Critical Control Point method of food safety management. It is a step-by-step risk analysis and control technique used in food industries worldwide to analyse processes and so identify food safety risks. It is a pro-active management technique for preventing hazards from occurring and reaching consumers, rather than reactive (fire-fighting) management methods of damage control. HACCP requires an objective assessment of all biological, chemical and physical hazards to human health throughout a business's operations and the development of appropriate control, monitoring and data recording strategies. As a risk management tool, HACCP can also be used to assess risks to product quality and environmental risks. The HACCP technique applies the following seven principles:

- Conduct a hazard analysis—identify all biological, chemical, physical and quality hazards.
- Determine the critical control points—the points in the process where risks are likely to occur.
- Establish critical limits—boundaries/tolerances for safe operation at the critical control points.
- Establish a system to monitor control of the critical control points.
- Establish the corrective action(s) to be taken when monitoring indicates that a particular critical control point is not under control.
- Establish procedures for verification to confirm that the HACCP system is working effectively.
- Establish documentation concerning all procedures and records appropriate to these principles and their application.

A HACCP plan essentially requires asking at each point in the process:

- What safety or quality hazards are associated with this process?
- Which of these hazards are significant and likely to occur if not controlled?
- What must be done to control these hazards to an acceptable level?
- What records or evidence are needed to demonstrate that the hazards have been controlled?

Implementation of HACCP is guided by scientific evidence of the risks.

The intent of HACCP is to focus control at critical control points. The individual operations within a business are identified, and HACCP principles are applied to each specific operation separately.

Consideration must also be given to raw material inputs such as water, fertilisers, packaging materials, and so on, which may be the source of problems. Hazard control measures may potentially introduce new hazards of their own and must also be considered.

When a significant hazard is identified in a specific operation, control measures must be established that prevent, eliminate or reduce the hazard to an acceptable level.

The critical limits (tolerances or safe operating limits) for that operation must be established to maintain control of the hazard, and an appropriate monitoring and recording procedure must be developed to confirm that hazard control is achieved.

Sometimes the monitoring may indicate that hazard control was not effective—that is, the operation exceeded critical limits for safety or quality—and corrective actions are required. Corrective actions are planned responses to a breach of safety or quality limits and the response must:

- identify the affected product
- determine what is to be done with affected product after assessing the severity of the problem
- determine the origin of the problem
- take the necessary action to prevent the problem from occurring again.

The intent of HACCP is to systematically build safety and quality into a food operation to minimise the chances of unsafe product entering the market. HACCP plans are fully compatible with quality management standards in food businesses for 'control of production' requirements. HACCP plans can work in combination with other support programs such as:

- good manufacturing practices
- pest control programs
- staff training
- cleaning and sanitation procedures
- calibration programs
- preventative maintenance programs
- document and record control

They can also constitute a business's Food Safety Plan.

Development of a HACCP plan will identify the requirements of a business to implement these support programs. The food standards will require all food production and handling businesses to develop an auditable food safety plan. The degree of complexity required in a food safety plan will reflect the complexity of business operations and the type of product and its associated risks; that is, the food safety plan for a small grower may be far simpler than that for a larger, more complex operation, although the same principles apply.





Potential markets exist for organic vegetable seed and seedling production.

In summary, changes in the expectations and buying behaviour of consumers are affecting agricultural producers. Globalisation of the food supply and the changing structure of fresh produce retailing in response to consumer trends are creating new challenges and dilemmas throughout the food supply chain. Research indicates that buyers are becoming more discerning about quality from the health and eating perspectives, and food safety is increasingly the primary concern.

Opportunities exist for organic and biodynamic producers to capitalise on these market trends through their 'clean and green' image with consumers. But close attention to customer requirements for quality and consistency, coupled with the need to satisfy food regulatory authorities in relation to food safety management, is required to realise this potential. Quality systems cost time and money, but these costs must be weighed against the substantial financial and potential legal costs of getting it wrong. Quality management is pro-active. Use of HACCP-based quality systems can accommodate food safety, quality and environmental business objectives.

The pace of implementation of quality management systems for quality assurance in agricultural industries is rapidly increasing. Quality assurance does not guarantee market premiums, but it will increasingly determine market accessibility. Quality management is rapidly becoming an essential management tool for producers in all food industries who want to do business better and remain competitive.

6.2 Environmental management systems

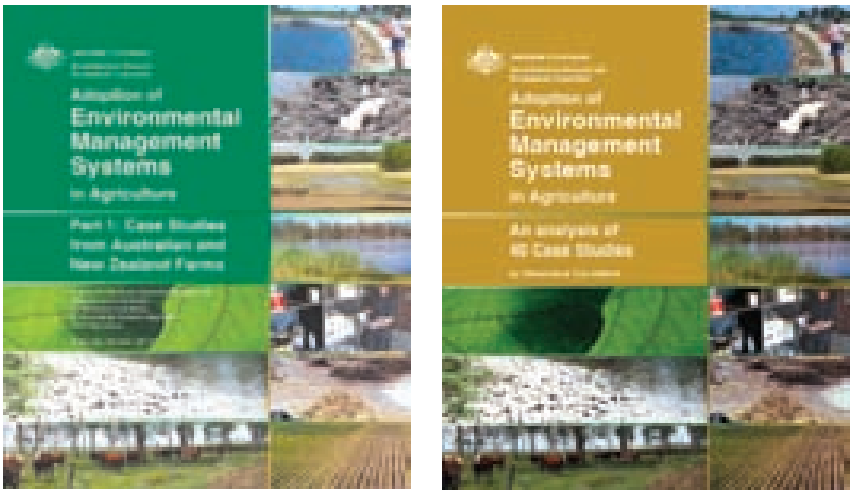
[This section is reproduced from *Marketing Organic and Biodynamic Products: conference proceedings* (NSW Agriculture, 1997). Genevieve Carruthers, Environmental Management Systems Specialist, NSW Department of Primary Industries, contributed what follows.]

> Environmental management systems (EMSs) are based (in general) on the principles of total quality management (Netherwood 1996). The British Standards Institute (1994, cited in Netherwood 1996) defines an environmental management system as 'the organisational structure, responsibilities, practices, procedures, processes and resources for determining and implementing environmental policy'.
>
> This definition, describing British Standard 7750 (which has now been withdrawn with the ratification of ISO 14000), is similar to that which could be applied to the Eco-Management and Audit Scheme (EMAS) and to Canadian and Irish environmental management standards and guidelines. All these schemes follow the total quality management loop approach—that of plan, do, check and act. A feature of the ISO 14000 standards is the requirement to achieve continual improvement of the system and therefore in the environmental management overall.
>
> Whereas quality control and assurance programs have focused mainly on the production of consistent goods and services, environmental management schemes have a broader focus—that of examination of the whole process of production of goods and services and the effect of that production on the environment. That is, not only will goods be produced according to the same set of standard procedures, but the effects of producing that product, be they pollution, use of resources, or transport of the completed object or delivery of the service, are also taken into account.
>
> In agriculture, the growing of beef cattle is an example. Not only does (or should) the farmer want to be able to produce a consistently high quality

product, but s/he should also consider the way in which the cattle are treated during the production period, the effect they have on the soil, water and air quality on and off the farm, ways in which the cattle are transported, the potential impact other farm activities might have on the cattle (use of pesticides, for example), packing of beef produced, and so on.

In their development, environmental management systems all follow much the same path. In the case of ISO 14000, there are five steps to developing and using an EMS:

- *Commitment and policy.* Here commitment is developed at all levels of the business or enterprise, from management down to the most junior levels. The policy is defined and developed.
- *Planning.* This is where the policy is translated into things to be done. A number of steps are usually involved, from a review of the environmental aspects and impacts of the business, the identification of legal requirements for compliance and the setting of objectives and targets through to establishing the environmental management program.
- *Implementation.* This is the 'doing' of the plan. This phase requires the provision of resources and support mechanisms to ensure that the environmental management plan is achieved and may include staff training programs to ensure that the objectives of the policy and plan can be met.
- *Measuring and evaluation.* This phase checks to see if the objectives and targets previously established are being met. Such methods as environmental performance evaluation, laboratory analyses of emissions, financial records examination and staff understanding of training programs may be used to assess whether the environmental plan is being met.
- *Review and improvement.* Here the data gathered in the previous phase are put to use. Were targets met? If not, why not? What can be improved? What worked well and why? ISO 14000 specifies that continuous improvement of the management system—note: not the environmental performance—is required.



Environmental Management Systems in Agriculture (Part 1 and 2)—Case Studies from Australian and New Zealand farmers *by Genevieve Carruthers. RIRDC publication numbers 03/121 and 05/032.*

The various environmental management systems differ in how prescriptive they are with regard to the ways to achieve improved environmental management. ISO 14000 does not specify particular environmental targets; these are set by the person/company/business setting up the EMS. However, all schemes do require that the EMS developed must use as minimum standards legislated requirements and/or (if available) industry codes of practice or best management practice.

In the case of an organic farmer, the required specifications would be one of the AQIS-accredited organic certifying organisations' standards, in addition to any current legislation (federal or state), as well as industry codes of practices to suit the particular enterprise.

Use of EMSs and organic farming to achieve environmental health

The use of EMSs is one tool in a range of methods designed to facilitate the management of agricultural land, using a system-based approach rather than focusing on crisis management. Organic farming is also a way of examining the whole system of farm operations, starting with soil health and its overall effects on farm components through to all facets of production. The difference really is one of degree: use of an EMS is not prescriptive in terms of what can be used on the farm but does specify that all operations and processes used on the farm need to be considered in the light of their potential impact on the environment—the so-called cradle-to-grave approach.

Organic farming may look at

all those elements but, to gain organic certification, there are a number of products and farming practices that cannot be used. This does not mean that use of an EMS cannot be made effective on an organic farm, but it does mean that using ISO 14000 as a guide will not result in an organic approach, unless that is the stated intention of the system in the first place and actions are matched to the chosen organic standard.

Author's note

A Rural Industries Research and Development Corporation report, *Green Marketing and EMS* (RIRDC publication number 04/175), states:

> A key finding is that the meaning of the labels 'sustainably produced' and, to a lesser extent, 'environmentally friendly' are confused and, in contrast to 'organic', not widely agreed by the industry or consumers. This confusion, and the assessment that currently there is relatively insignificant demand for sustainably produced food, will result in considerable delay in the eco-labelling of food products …
>
> The findings of this study concur with international experience that there is little clarity regarding what green, sustainable, or environmentally friendly production systems mean and what benefits these systems deliver to the consumer. This suggests a necessary, but not sufficient, condition for progress in green food marketing is that clear protocols, guidelines and accreditation processes must be established if generic labelling is to be adopted to communicate the benefits to consumers and facilitate the market development for sustainably produced food products. (Cary et al. 2004, p. vi),

It is clear from these comments that organically certified products are well accepted in the marketplace and that the market advantages of adopting an environmental management system are yet to be recognised.

6.3 Marketing

Organic producers use a variety of marketing techniques. The market destinations are domestic (local and interstate) and export sales. The following are among the domestic distribution channels for organic produce:

- direct farm sales
- local, regional and city farmers' markets
- wholesale and retail
- processors
- home delivery
- internet sales
- mail order.

Some producers add value to their farm produce on the farm. Others tend to do little on-farm value-adding. Some farmers cooperatively sell their produce to processors, who then add value by processing (snap freezing, for example) and packaging the product.

Quality, continuity of supply, product range and service are central concerns for purchasers of organic products. Many consumers bemoan the fact that a regular, year-round supply of consistent-quality product is often unobtainable.

Gibson (1995) puts forward 50 farm marketing tips that should be compulsory reading for marketers. They can be found at the Australian New Crops website: <http://www.newcrops.uq.edu.au/newslett/ncnl1112.htm>.

6.3.1 Marketing alliances

Producers can benefit from developing marketing alliances. Such alliances allow producers to work together to research, locate and gain access to markets.

Production alliances give purchasers of organic products access to a range of products through one avenue and the potential for a year-round supply.

Two types of marketing alliances appear to dominate organic production:

- *Diverse product alliances*. This involves producers in forming regional alliances based on promoting the regionality of specialty products. These alliances are characterised by production of diverse commodities and may entail a high degree of value-adding. Such groups generally target local, gourmet and specialty markets.
- *Parallel product alliances*. This involves producers who produce like products (for example, potatoes and carrots) in marketing to a central distributor or processor. These alliances might involve minimal on-farm value-adding of a bulk commodity.

One example of a parallel product alliance is Heinz Wattie's Australasia, which pioneered large-scale commercial organic vegetable cropping in New Zealand and is acclaimed as an industry leader.

At present, the organisation processes organic peas, carrots, sweet corn, green beans, broad beans, potatoes, squash and onions. Its organic products are marketed in New Zealand, Australia, Japan, South Africa, Europe, Canada and the United States.

All suppliers and processing facilities are certified as meeting the production standards of BIO-GRO NZ, an independent certifying agency, and the organic products carry the BIO-GRO trademark. Heinz Wattie's Australasia supplies technical advice and assistance. New growers are helped through the BIO-GRO certification process. Newsletters, field days and discussion groups keep growers up to date with the latest information.

Heinz Wattie's Australasia started its organic program in 1990, with a 7-hectare crop of peas in Canterbury, New Zealand, and production has been growing steadily ever since. The company now has about 60 BIO-GRO-certified suppliers in New Zealand, most of whom have converted from conventional cropping practices.

Now over 2500 hectares are available for organic crops. The organisation expected to process about 6000 tonnes of various organic crops in the 2000–01 season.

The first step in successful marketing is for producers to define their production and supply pathways; then they must introduce effective supply chain management.

6.3.2 Defining production and supply pathways

Producers considering selling any product first need to define who the consumer is, what product is to be sold, where the consumers are, and how the product will be transported and processed.

What follows is from a presentation by Barry MacDonald, formerly Market Development Officer, NSW Department of Primary Industries, to the Organic Production Workshop (Rangeland Livestock), Hay, September 2002:



Tweed Richmond Organic Producers Organisation member Dave Robey proudly displays promotional material for the newly created Rainbow Region Organic Market at Lismore. Photo: R Lines-Kelly

Focus on pathways

Consumers are the focus of production pathways. Consumer protection is paramount. Pathways need to be defined. This includes on-farm practices. The direction of pathways needs to be determined, and guidelines and specifications need to be developed to meet these requirements.

Communications

Communications/ documentation must be developed to facilitate the marketing process. The origin of the product needs to be verifiable, so a system of full traceability is essential. Organic producers need to be able to prove the organic history of the product in order for consumers to have confidence in the product. Accreditation and certification will achieve this. Marketing and promotion of the product should be undertaken by the producer or supplier. Use personalised logos on labelling; tell 'your story'.

Substitution

Substitution is occurring in the marketplace—non-organic meat being sold as organic, mislabelling of cuts, and so on. Producers must have confidence they can prove their accreditation and the authenticity of their product. Truth in labelling and the correct naming of the product are essential.

Processing specifications

Processing specifications for a product involve establishing guidelines at key points in the production pathway. These include the farm, transport, slaughter, boning room, during any further processing, packaging, distribution, at the retailer or purchaser, and during the display of your product. Feedback sheets provide an opportunity to gauge consumers' response to the product but can also be included at other key points in the pathway. Maintaining awareness of how the product is performing at all key points is essential.

Further processing (value-adding)

As a producer, you need to determine if you will produce traditional market cuts and/or value-add to product cuts. Value-added products include prepared meals, heat-and-serve cuts, pan-ready cuts, and oven-prepared and gourmet (for example, pate) products. If the product contains other ingredients, such as herbs, and is being marketed as organic, proof of the other ingredients' organic certification is also required.

The consumer

Consumers must be willing to pay for the organic product. This will tend to limit markets to health-conscious, middle and upper class consumers. It is important to identify where the greatest demand is—for example, affluent city suburbs—and what type of product will be in demand.

The product needs to have purchasing appeal (good presentation, and so on) and it is important to instil in purchasers confidence in the product. Information such as cooking methods can accompany the product. A consumer who is happy with your product will come back for more.

In summary, pathways between the producer and consumer need to be defined. Market specifications, codes of practice and quality assurance need to be implemented. Credibility in the marketplace must be gained. Marketing alliances allow for supplying year round, but will only be successful if participants work together to develop the market pathway, become involved, and stay aware of the program. Communication is essential throughout all the supply chain.

6.3.3 Supply chain management: the key to successful marketing

The key to successful marketing, whether as an individual or as a group, is effective supply chain management. The individual or group must be active and maintain communications and interest in the entire marketing process. Successful producer alliances follow their product throughout the marketing pathway to track its performance—all the way to the consumer—and are prepared to diversify. Figure 6.2 illustrates a supply chain model for organic products.

Supply chain management can be defined as 'a business strategy that sees the whole chain as the competitive unit, not the individual firms within that chain. This strategy depends on the firms within the chain learning to work together. Working together builds better relationships between firms and is a way of creating more value for others in the chain, especially consumers' (AFFA 2003, p. 3).

The following are important considerations for organic producer alliances seeking to export:

- organic credibility
- year-round supply
- selection of a processor sympathetic to their aims
- selection of suitable trading partners.

Organic credibility

Producers must understand and implement an organic certification scheme that meets their requirements as well as those of their customers. Ideally, a single certifier should certify each property in the producer alliance. Not all importing countries or customers recognise the standards of each Australian certification organisation, so it is important to choose a certifier whose standards are recognised by the country where or the customer to whom the product will be sold.

Clear and precise documentation will assist with marketing the product, and the group will be able to demonstrate to potential customers full traceability of the organic product. Specific standards might need to be developed for transporting and handling, these then being endorsed by the organic certifier. It is advisable to conduct trial runs with the product in order to expose any potential problems that could call its organic status into question. Full documentation that clearly alerts produce handlers to the organic status of the product is also necessary.

Year-round supply

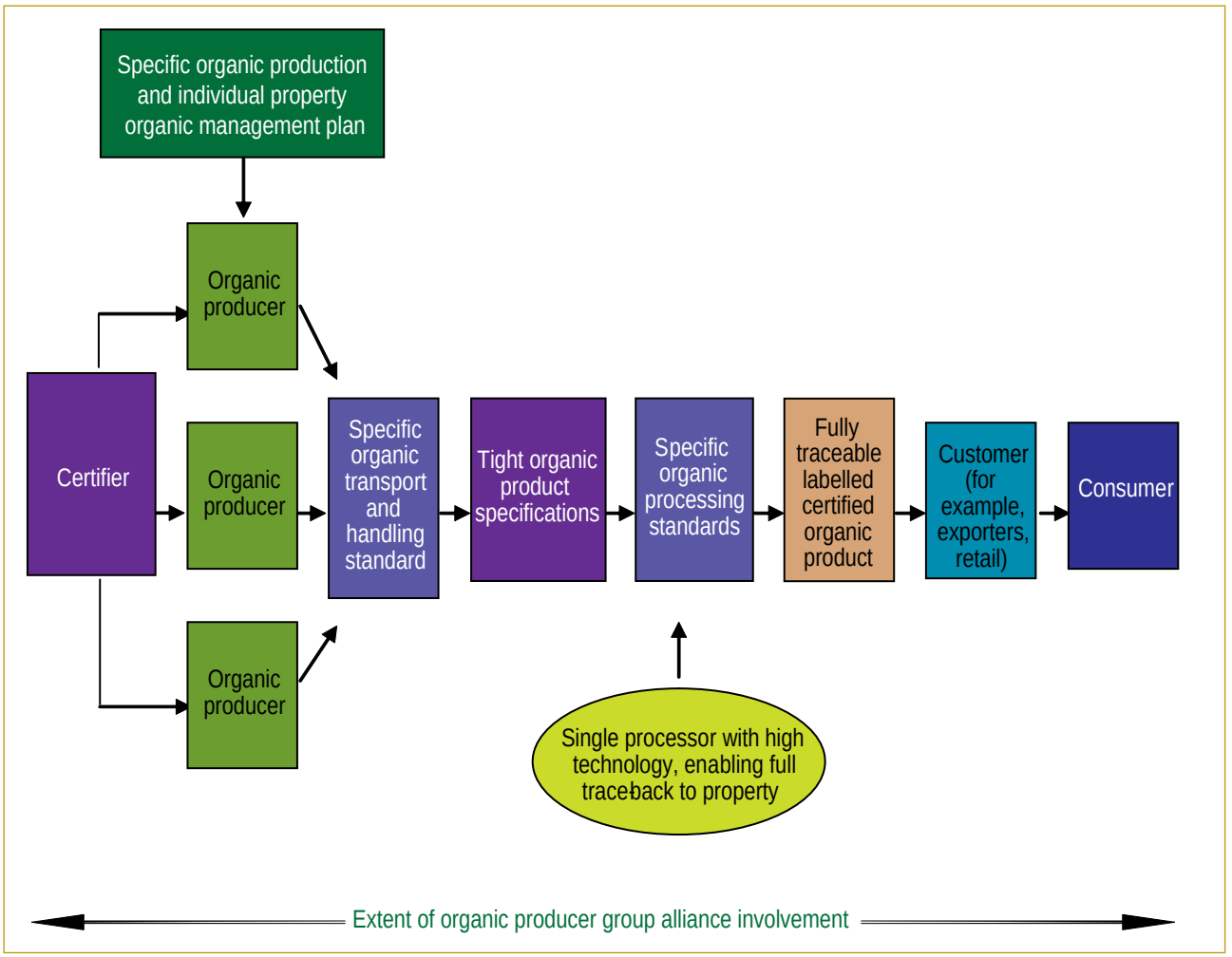
Consumers are unlikely to be interested in a product for which year-round supply cannot be guaranteed.

Cooperation between members in a producer alliance is the key to obtaining a year-round supply of quality product. Harvesting and marketing of crops needs to be scheduled within the capacity of each individual property: people will manage their operations to grow and finish within the capability of their resource base. This might, however, vary from season to season and locality to locality.

In order to have a year-round supply, year-round production data for each property should be thoroughly assessed and all options should be investigated.

Choosing a processor

The processor chosen must understand the requirements of the group and the product. They need to be innovative and accept that the producers want to be involved throughout the entire supply chain. They also need to agree to



Source: Adapted from Pahl (2000).

Figure 6.2 The supply chain model concept for organic products

be certified to process the organic product and have the requisite export clearances for the markets the group is targeting.

If not already certified to process organic products, the processor should establish procedures and standards that ensure the segregation of the organic product throughout the processing plant, including packaging and storage for shipment. Full traceability to each farm, and even paddock, will need to be demonstrated.

6.4 Product promotion, packaging and presentation

[This section is reproduced from *Marketing Organic and Biodynamic Products: conference proceedings* (NSW Agriculture 1997). Catriona Macmillan, Heaven & Earth Systems P/L, contributed what follows.]

Key elements in selling organic products are promotion, packaging and presentation. Organic products generally command a premium in the marketplace. Consumers paying a premium price expect a quality product that looks well packaged and presented. Further, the consumer needs to be educated about why they are buying a premium product—promotion. Consider a number of promotional ideas:

- *The product being sold is organic, so put the word 'organic' on the label.* Research has shown that 12 per cent of Australian consumers are interested in organics. It is up to you to harness that interest into profitability. The competition is tough, a world of multinational companies who can and do spend millions trying to convince the consumer their product is what our product really is—environmentally responsible, natural, clean and green. Organic is unique product and needs to be promoted as such.
- *Participate in joint promotional opportunities.* Organic farmers have regularly participated in and promoted their produce at the Royal Easter Show in Sydney, which over 1.7 million people visit each

year. Your participation not only gives your products and produce exposure but educates the consumer.

- *Tell your story; this is what makes your product interesting.* Consumers love to hear your story. The consumer wants to be able to say, 'I made this little dish out of organic rice. The rice farmer doesn't burn the stubble, just allows it to build soil fertility', and so on. Remember you are selling your product/produce to processors, exporters, wholesalers and the consumer, whether it is a brochure, a label or your letterhead, the consumer wants a story. Why do you grow? Why do you care? How do you grow? You don't have to reveal all. A graphic and a few words can say a lot.
- *Promote your farm using farm tours, open days and school tours.* Excellent examples of farm tours are Montrose farms, Kiwi Down Under and Glenbye. Montrose farms offers 'pick up your own berries in picking season', 'tour of the charming 1860s homestead' and 'bed and breakfast'; they also offer 'afternoon teas, with hot country-style scones and homemade berry jam' and you can hold your 'wedding reception on the lawns'. Kiwi Down Under has won numerous tourist awards, and 12 000 people go through a year. It has a tea house, organic food market, informative farm tours, animal feeding and nature walks. Another highly innovative farm, Glenbye offers 'Glenbye Getaway Tours', a package including air fares for parties of ten. Riverina organic rice farms regularly host tours for Japanese farmers and overseas trade delegations.
- *Promote your farm and produce.* Send brochures or newsletters to your local library, schools and tourist office. Advertise with your state tourist board and holiday magazines. Develop a mailing list, including everyone who has visited your farm in the past, and post a newsletter … to inform people of new products or dates for the next 'pick-your-own weekend'. You could include some other local events or sights in your area. Investigate any ecotourism projects in your area. Do you have any features that the Eco Tourism Association of Australia would endorse? Hold open days and field days: organise your own or look for opportunities, for example, in 2001 ABC open farm schemes held their annual farm open day with four Victorian organic farms. Let the local paper know of any special events, attach a brochure or newsletter to a very brief and simple press release. Start a school farming project to encourage visits.
- *Mail order delivery.* In the United States and the United Kingdom a great deal of trading in organics is done by mail order. Producers advertise in the major health and gourmet magazines.
- *Promote yourself on the world wide web.* American and European companies have mail order, home delivery and promotions on the web. If you have a website, you could include your web address on your label. In Australia some trading and information sites are being developed.

What product?

Identify the trends, choose the market for your product, and package and present your product in a way that will sell it. In other words, are you planning the right product, and are you growing produce that will sell next season?

Note what organic products Australia is importing—for example, organic cornflakes from the United States and the United Kingdom. We also import tomato sauces salsas, olive oil and Californian dates, and we pay a premium for them. Note how these products are presented. Why will a consumer pay $6.50 for imported organic cornflakes? The packaging and quality account for a lot.

Remember, fads and fashions change. Investigate, look at conventional models: pasta sauces hardly existed on supermarket shelves in the early 1990s, but look in the supermarket now. Chilled, and particularly prepared, dishes are filling the shelves. Consumers even want to buy salad dressing ready to pour. As Reg Clairs, CEO of Woolworths, said, 'Meal solutions will be the single most important revolution for supermarkets over the next five years'. People want dinner on the plate, not the ingredients in the shop.

As organic producers, are you investigating organic meal solutions, frozen meals, frozen vegetables, salad mixes, dips, deserts, pasta meals, chilled vegeburgers, as well as the more traditional deli ranges of chutneys, jams, sauces and pickles? What about frozen juices, fruit juices, muesli bars and cornflakes?

If you are investing in labour and machinery, invest in research and advice too. Include packaging and marketing in your costing.

Farmer and consumer need to get together: look for every opportunity to find out what the consumer buys. Ask your friends, everyone you meet; ask them why they buy. Visit the city.

What supermarkets need

Recently a spokesman for Coles Myer Ltd said they were now working closely with smaller food companies in a bid to offer a wider range of products, particularly at the gourmet fresh food end of the market. Unlike the big brand names, which offer special marketing deals to the supermarkets to claim the best shelf positions for their products, organic businesses have not spent millions on advertising and promotion. Some supermarkets will expect you to give in-store demonstrations and food tastings.

Supermarkets usually trial a line for a season to see if it sells: if not, it is out. They also have specific packaging needs—for example, barcodes and particular sizes and shapes for stacking.

A reliable and regular supply

In Britain the success of fresh organic fruit and vegetables in supermarket chains was the result of a wholesaler checking what the supermarkets needed. The wholesaler packaged the produce so that it could be easily identified as organic and stacked easily and also provided efficient and reliable delivery system. Sainsburys, a UK supermarket chain,



Organic meal solutions: heat and serve, a trend for the future? Photo: MacDonald (2002).

has sponsored major organic industry events and has a program in operation to encourage conventional farmers to convert.

When Sainsburys advertises nationally it simply lets consumers know it sells organic as part of its range. It also sponsors the organic industry to promote and educate the public on the value of organics.

What department stores need

Packaging, shelf life and presentation are just as important to department stores. David Jones is very interested in a line of organic flour that comes in calico bags. It thought the 'calico' look outweighed the problem of stacking and shop soiling—that is, the bag looking grubby from dust—although the top-stitching has to be sewn straight and parallel to the edge. The buyers for David Jones have said they would order more organic products if the labelling and packaging were improved.

Grace Bros' preferred packaging for Glenbye's organic wool quilts is a firm, transparent plastic case rather than a calico case. Why? Plastic will not become shop soiled, it can be dusted, it can stay neatly stacked, and it can be handled and still look bright and shiny over time. Using plastic rather than calico may seem an environmental contradiction, but shop soiled means selling at a discount.

What small shops need

Customers like variety. They come in to be entertained: a fruit and vegetable shop is like a theatre with live daily performances—the display. What is needed is a constant supply of quality staples plus something new and seasonal. Find ways to have your produce tasted.

Brochures, newsletters and logos

Prepare a simple but professional-looking brochure explaining what your farm sells, plus 'your story' and who you are certified by. Use it like a business card. Or send a leaflet providing recipes out with consignments.

Newsletters could be posted, perhaps quarterly. Tell readers about the harvest, any new products, what is in season,

field days, and so on. Select dates for farm tours, explain why you dug in your lettuces, as opposed to spraying after a bug invasion; and why there were no carrots last month. Do you do mail order? Include your latest product list with your newsletter. Macro Wholefoods is a large Sydney wholefood store; its newsletter acted as a brochure and contained a recipe, some Christmas shopping ideas, the business's mission statement, and a map showing the business's location. A newsletter can cost less than a glossy brochure, especially if printed in one colour, and can be more readable, with new ideas presented in each issue.

Logos can be a powerful tool for recognition. Note that, when selling to different cultures, a healthy green image or name could translate into an inauspicious image. It is also possible to label individual pieces of fruit, to distinguish them from conventional produce.

The environmental predicament

When it comes to packaging and presentation, there are conflicts between organic principals and retail demands.

- Consumers have high expectations and unrealistically want perfect-looking produce.
- Consumers assume that if it looks hygienic it must be healthy that sterility equates with goodness, and that soil on potatoes and lettuces means germs and work to clean. Fear of food contamination is also a great concern for retailers and consumers.
- Organic broccoli travels better in ice and polystyrene, but what does the polystyrene do for the environment? The consumer wants fresh-tasting and -looking broccoli.
- Some consumers want 'environmentally friendly' claims—such as 'dolphin safe', 'chemical free', 'phosphate free' and 'recycled paper'—because these claims inundate retailers' shelves already.

We need to find ways of responsibly managing these conflicts when labelling and packaging.

Seasonality

Some organic food is not available year round. In both Europe and the US 'being in season' has become a selling point. Extending supply could include processing the product or specialised storage.

The Earth Food store in Sydney sells an organic apple pie. As soon as the new apples are in season the regular customers start anticipating the arrival of these freshly baked pies. Consumers need to understand why product is not always available, so it is important to communicate with the retailer.

Labelling

Labelling is an important component of packaging. Labelling should be informative and legally correct. Following are a few pointers:

- Often the label is built into the packaging, as opposed to being stuck on.
- Always identify your certified ingredients as certified organic.
- Labels need to be attractive: bring in a designer.
- Sell the positives, not the negatives—for example, 'we build soil fertility'.
- Every label tells a story: let your label tell your story.
- Include 'free range' when applicable. The customer often assumes that free range is as good as organic, so explain what your organic poultry and livestock are fed—for example, organic grain on an organic farm. Another misconception is that 'tree ripened' and 'sun-dried' mean organic-type harvesting and no chemical preservatives.
- Take pride in your product. Label and box your produce,



Logos can be a powerful tool for recognition. Personalise them and they can leave a lasting impression.

and each time your name and product are displayed check the standard.
- Try out a label and package and gauge the responses in the real market—in Bondi, not Bourke. Ask your friends in the city.
- Check packaging and labelling laws in your state. The New South Wales Department of Fair Trading can direct you to the relevant government departments and statutory bodies.

Legally you are required to provide certain details on the label. State or territory and federal laws, as well as the laws of importing countries if you intend to export your product, apply. In New South Wales, the New South Wales Food Authority can provide information on correct labelling (see Appendix A). The National Standard for Organic and Biodynamic Produce describes the requirements for labelling organic products destined for export and those for imported organic products.

The following is a basic checklist for labelling packaged food:

- name of the food
- the ingredients, in order of volume
- the name and address of the maker, packer, vendor or importer
- the country of origin
- the batch code
- the sell-by date or a date stamp
- sugar-free, low-fat, and so on, nutritional content—keep claims and information simple, realistic and relevant
- claims that can be verified
- a notice to refrigerate after opening where relevant

If you are exporting, some countries might require additional nutritional information, and the label might need to be in a language other than English.

Promotion and the media

If a story about your organic produce and how healthy it is is published nationally, suddenly consumers want organic. When promoting nationally, promote realistically.

Australia has a small population spread over a large land, so how can we promote a relatively small industry nationally when it is spread over such an expanse? Industry promotion such as an 'organic harvest' provides an opportunity to promote locally and nationally. Its main purpose is to educate consumers. The organic harvest is a national event where the focus is on promotional events at the local level. Activities are held over a month and can include everyone, no matter how small. Publicity for such events can be generated through networking, coordinated media releases, using celebrities and linking with other promotions.

6.5 Export help

[This section is reproduced from *Marketing Organic and Biodynamic Products: conference proceedings*, (NSW Agriculture 1997). Jim Murison, Previously Manager, Agsell[1], NSW Agriculture, contributed what follows.]

When thinking about export, the first step is to examine the reason for exporting. What are you going to achieve by exporting rather than selling in Australia? Do you have goals you wish to achieve, and within what timeframe do you plan to achieve them? Do you have the funds and time to devote to this project and, importantly, enough product to satisfy the market if you become successful? Can you obtain more product from others if you are not able to meet the requirements yourself? These questions must be part of your evaluation.

Having evaluated your position and decided to proceed, the next step is to select the markets you are interested in and find out if they are interested in you and your product. There may be no demand for what you produce if it is not part of that nation's culture. You also need to determine if the importing country recognises your certifier's logo or if it requires you to carry its logo, in which case there will need to be an agreed equivalence with your certification organisation.

Austrade can provide general information—for example, information on price, packaging, suitability and trends—on the market in locations throughout the world. The information is provided on a fee-for-service basis … If you have difficulty in meeting this initial cost, exporting is most likely out of your range of options.

Once the market needs are known it is time to inspect the chosen market personally. Taking samples of your product is suggested if it is possible. Business cards and a brochure in the local language are needed. Introductions to businesses that are interested in your product can be made by Austrade and, in some areas, by the Department of State and Regional Development, as well as Agsell.

Another way of meeting people who could be interested in buying your product is to exhibit at a trade fair. Many

[1] *Agsell is now known as Primex*

are held throughout the world each year. There are often state-organised displays at these fairs, and this can offset the costs involved in mounting a display by yourself. Agsell has organised such displays at selected trade fairs in Japan and Korea, with success for the participants.

Once the contacts have been made the difficult part begins. It involves trial shipments, altering the packaging, changing the size and a number of ingredients, and many other incidentals. A freight forwarder conversant with the rules of your chosen market is essential for forwarding samples and product to your overseas representative. It will be invaluable in handling problems of customs, quarantine and officials involved in gaining entry to a market. The fee is well worth the service provided. Before agreeing on final orders, a number of trips by both parties to each other's business is essential. Then the real price of each unit can be negotiated.

Often Australians give a price on a take-it, leave-it basis, while Asians will ask for alterations on the assumption that the price offered will cover the alterations. It is also important to keep your brand on a product for as long as possible, so there is no confusion about the product's origins. Follow-up information is highly recommended to keep final sellers informed that it is your product they are selling.

Vital for any producer is a quality assurance scheme that will guarantee to the purchaser of your product that it is safe and of the best quality. It also assures the buyer that what they are buying is the same as the last purchase, since success is based on people returning to buy more.

New exporters often fear not being paid. Your bank can help in this regard by nominating a number of ways to ensure that you get your money. There is a charge involved, but it is one way to be confident about being paid when you first start exporting. Methods of guaranteeing payment range from letters of credit secured against your consignment to cash transfers, insurance coverage, and even banks paying you the agreed price and then recovering the money from the buyer. Being paid is not usually a problem in most Asian markets.

Agsell is the marketing arm of the NSW Department of Primary Industries. Agsell's role in the export business is to assist exporters and buyers. It can introduce an Asian buyer to a producer of a product such as organic pasta and assist in overcoming problems with exporting that product. Many overseas groups like to deal with government agencies as a first step in contacting suppliers. Agsell is that first port of call for intending buyers of New South Wales produce.

The same conditions apply to organic products for export as for any other product for export. There must be a market for the product and the price must be high enough for the exporter to make a profit from the sale.

To avoid health problems with a range of foods, consumers in Europe and Japan are buying organic food in the belief that it will overcome food contamination. But organic production cannot guarantee that protection. A quality assurance scheme is required.



Display of organic products in an Asian supermarket

The Japanese market is going through an 'organic' phase. Japanese purchasers will want only certified organic products. Suppliers in Japan do not meet the high standards set in Australia. The price offered will often not reflect the fact that the product is certified organic by a recognised Australian organisation. Japan is the largest market for organic produce. There is a limited market in Singapore and Hong Kong, but the rest of Asia is still coming to terms with supermarkets and year-round fresh food.

European markets are large and, because of the wealth and number of consumers, there is demand for organic products during the northern winter. Competitors would be Mediterranean and African countries that are close to the cities of Germany, Holland and the United Kingdom. Many of these producing countries have preferred entry to the European Union, so competing on an equal basis might not be possible.

Agsell is often asked to seek a source of product that is not grown in New South Wales. There could be a need to import planting material and work closely with research staff to develop the product to meet the buyer's requirement. The intending buyer might also contribute to the research work to help speed up the process of developing a crop.

Export is not for everyone, and a strong domestic base is almost essential before moving to export. Most exporters use the export market for their top-grade product, seeking a higher price than the domestic market. Export can also be used to reduce an oversupply on the home market and establish price stability in the home market. Sending product to export markets on an infrequent, or 'spot', basis rarely pays in the long term, and it does very little to develop a long-term profitable business domestically or overseas.

6.6 Processing requirements

The processing, packaging and labelling of organic product must conform to organic standards. Commonwealth and state or territory health and food safety laws must also be adhered to.

The national standard states that, in order to be sold as organic, products produced organically '… must be handled in a manner which would prevent contamination or substitution with substances or products not compatible with this Standard'. This means that processing facilities must be pre-cleaned of substances not compatible with the standard prior to processing of organic products and that storage areas for organic and non-organic products must be segregated.

Careful identification is also required to ensure that mixing of organic and non-organic products does not occur. To assist with this, the national standard states, 'An operator should have in place a quality management system as an integral part of the organic production system … and … this should be compatible with Hazard Analysis Critical Control Point (HACCP) principles'.

The national standard requires that off-farm processing facilities be inspected and certified. Processors must apply for and undergo an inspection before processing an organic product. On-farm processors of organic products must be inspected and are required to provide a quality management manual for the operation.

Processing and food preservation techniques must comply with organic standards. The use of additives and processing aids is restricted to situations of demonstrated technological need, where food safety might be compromised or where the aids are essential in order to prepare, preserve, or minimise physical or mechanical effects to a product. Sometimes Commonwealth and state or territory law requires the use of such additives.

7. Regulatory considerations

7.1 Export requirements

[This section is reproduced from *Marketing Organic and Biodynamic Products,* Conference proceedings (NSW Agriculture 1997). It was contributed by Ruth Lovisolo, then Manager, Food Standards Policy, Australian Quarantine and Inspection Service.]

The potential for exports of organic produce has increased from a niche market in Europe to wide interest from consumers among a number of Australia's trading partners. To ensure that the integrity of organic produce is not compromised and to meet the requirements of importing countries, the Australian Quarantine and Inspection Service requires that all organic certification organisations be accredited for the purpose. A national standard and legislation underpin the third-party accreditation program and provide the mechanism for approved certification organisations to issue certificates to accompany organic produce to importing countries.

The stimulus for introducing an export facilitation program in Australia was created by the increasing world demand for organic produce and the need to provide assurances about the integrity of the product. European Commission regulations for the import of organic produce into countries of the European Union require the competent authority in the exporting country to oversee the organic industry.

By 1990 Australia had gained a niche market in the European Union for organic produce. While this market has continued to grow, since then other markets have also opened up for organic produce. Among them are Switzerland, Japan, the United States, Singapore and Hong Kong. All countries are being encouraged to harmonise their respective import controls for organic produce through the work of the FAO–WHO Codex Alimentarius Commission.

Any producer intending to export food or fibre that claims to be organic or biodynamic needs to know the following.

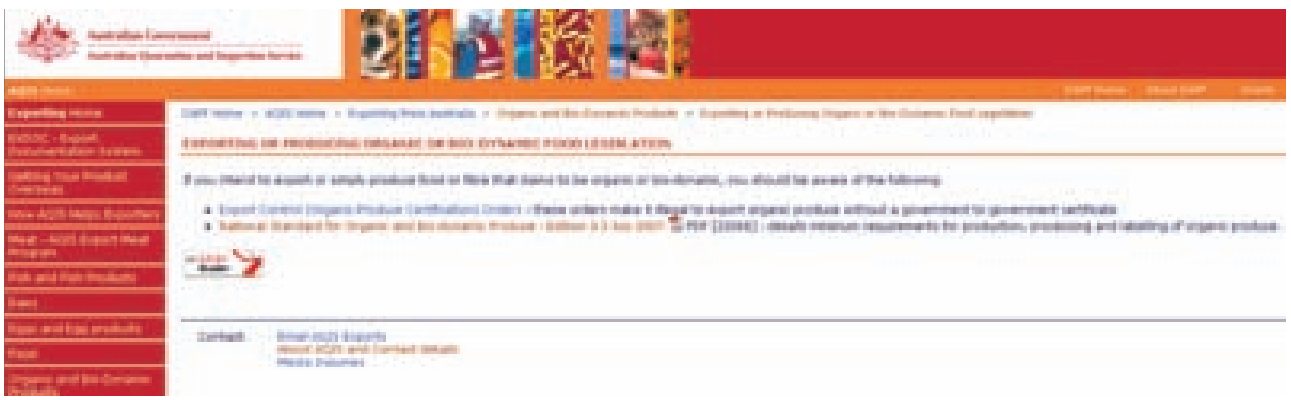
The National Standard for Organic and Biodynamic Produce

The Federal Minister for Primary Industries introduced the National Standard for Organic and Biodynamic Produce on 10 February 1992. The 3rd edition of the standard is currently available in draft form.

The standard sets out the minimum requirements for production, processing and labelling of organic produce. It also establishes the minimum requirements for inspection of individuals producing organic products and the minimum requirements for certifying such operators. Any producer or processor who wants to export produce that is labelled organic or biodynamic must demonstrate compliance with at least the requirements of the standard. This is achieved by being certified by one of the AQIS-accredited organisations.

AQIS accreditation

The national standard sets out requirements for industry organisations seeking to become 'approved certifying organisations'. This is achieved through a system of third-party accreditation. The basic approach to the audit program has been developed by AQIS in conjunction with the industry. The Administrative



http://www.daff.gov.au/__data/assets/pdf_file/0018/126261/National_Standard_Edition_3_3_1st_July_2007.pdf

Arrangements describe how certifying organisations apply to AQIS for accreditation.

Each certifying organisation is audited annually, as required by the European Union. The audit process involves a number of steps to ensure that the organisation and its members meet the requirements of the national standard. Individuals may be involved in one of these steps when AQIS verifies the inspection reports of an organisation on the farm or in the processing plant. By 2004 AQIS had accredited seven organisations to provide inspection and certification services for a range of organic or biodynamic commodities and production practices. Certifying organisations that are accredited by AQIS are listed in Appendix A.

Legislation

The Export Control (Organic Certification) Orders give 'prescribed goods' status to organic produce under the *Export Control Act 1982*. Any person producing organic goods for export is required to have a quality management system that is audited by AQIS as part of a third-party arrangement with certifying organisations.

All product leaving Australia that is identified by the trade description 'organic' or 'biodynamic', or with words of similar intent, such as 'biological', must be accompanied by an Organic Produce Certificate. The Orders provide the necessary authority for AQIS to delegate the issue of certificates to accredited organisations. Certifiers issue export certificates to the exporter of the organic product.

Cost recovery

Government policy requires that AQIS fully recover its operational costs. These costs are met by the certifying organisations. AQIS recognises the impact of such charges on the industry and has undertaken to minimise such costs wherever possible.

More information

Further information about the export facilitation program for organic produce can be obtained from AQIS (phone 02 6271 6638).

7.2 Permitted inputs

Although organic production standards promote non-reliance on external inputs, they do acknowledge that some intervention might be required at certain times during production. This could particularly occur during the conversion phase.

The national standard provides lists of permissible substances for correcting soil fertility, for combatting pests and diseases, for sanitation, storage and handling, and as processing aids.

Requirements for use of inputs are defined in the standard. Inputs are classified as permitted without restrictions on use or permitted providing specific conditions of use are met. Appendix B lists the permitted inputs.

Various commercial products containing the permitted substances have been developed, and certifying organisations have approved the use of some of these substances. All inputs must be recorded in the farm diary, and it is advisable to have any input approved in writing by the certifying organisation before using it.

7.3 Other regulatory considerations

As is to be expected, organic farmers are subject to the same legal requirements as other farmers.

State, territory and federal laws relating to things such as health and food safety, noxious weed control, fruit fly, feral animal control, exotic pest and disease outbreaks, and pesticide use must all be obeyed.

In some instances the use of chemical controls might be the only option for an organic producer.

If a non-permitted chemical must be applied, the certifier must be notified immediately and, although certification will be withdrawn, it might occur for a limited time only or apply only to a specific part of the farm.

In some instances the certifier might be able to negotiate with the statutory body responsible for administering the law to find a solution to the problem. Sometimes a non-chemical solution is possible. This needs to be clearly explained to the responsible statutory body, and a 'win–win' outcome will have to be demonstrated.

7.3.1 Chemical application permits

All chemicals used for pest and disease control must be assessed and registered by the Australian Pesticides and Veterinary Medicines Authority (formerly the National Registration Authority).

The authority evaluates all agricultural and veterinary chemical products and registers them for sale in Australia. Registered products can be used only in accordance with the instructions on the label.



All chemicals used for pest and disease control must be assessed and registered by the Australian Pesticides and Veterinary Medicines Authority

Off-label and minor use permits

Many minor crops, although significant in total value, are too small for agrochemical companies to accept the high cost of registering crop protection products. At times

it also becomes necessary to use agricultural chemicals for a use not specified on the label. To use registered or unregistered products in an off-label manner, an off-label permit must be obtained. The Australian Pesticides and Veterinary Medicines Authority recognises two categories of justification for off-label permits:

- *Minor use*. This refers to one or more of the following:
  - a specialty crop produced only on a small scale—that is, production of less than 500 hectares or $500 000 a year
  - a small percentage of a major crop—that is, less than 2 per cent of such a crop
  - a minor or infrequent pest or disease on either a minor or a major crop
  - when the method of application differs from what is described on the label because of unique local circumstances—that is, aerial application of a chemical registered only for ground application because local wet conditions do not allow ground application.
- *Emergency use*. This refers to a situation calling for a rapid response. The most common example is when it is necessary to control a new or exotic pest or disease for which there are no registered control products.

Applying for a permit

The Office of Minor Use, under a company called Crop Protection Approvals Ltd, has been set up to process and assemble off-label and emergency-use permit applications on behalf of AUSVEG-levied crops such as lettuce. CPA can be contacted by phone (03 8371 0001), fax (03 8375 7552) or email (Cpa@ cpaltd.com.au).

Otherwise, applications for off-label permits can be made directly on the approved application form and submitted to the Australian Pesticides and Veterinary Medicines Authority. General information and application forms can be obtained from the APVMA website <http://www.nra.gov.au> or by contacting the permit evaluator <http://www.apvma.gov.au/about_us/contact.shtml>.

The majority of off-label permits take between three and 12 months to be assessed by the APVMA. Genuine emergency uses are usually assessed in five to 10 days. No fee is charged for any applications received from primary producers.

7.3.2 Phytosanitary requirements

Access to export markets depends on a product's ability to meet the importing country's often stringent phytosanitary (quarantine), sanitary (for example, microbial contamination) and non-quarantine (for example, quota and tariff) requirements. Phytosanitary barriers relate to the possible presence of insects that are absent or of restricted occurrence in the importing country (Holmes & Kriedl 2003). Among the specified control measures are monitoring to establish area freedom status, pesticide programs, pre-shipment treatment with chemical and non-chemical agents, in-transit cold treatment, inspection, and/or fumigation on arrival.

Chemical treatments are becoming less common, but they are still relied on in order to gain access to some markets for some products. Chemical disinfestation of an organic product destined for export nullifies the organic status of the product, and this has limited the ability to export many Australian organic products, particularly fruit and vegetables.

A report published by Victoria's Department of Primary Industries collates the phytosanitary requirements for Japan, South Korea, Taiwan and the United States, identifies export market opportunities for organic fruit and vegetables, and recommends disinfestation methods and other phytosanitary controls that could satisfy export markets while maintaining the organic integrity of products (Holmes & Kreidl 2003).

The report recommends further investigation of a range of organic export market opportunities based on current market signals, market size and ease of access. These include navel oranges, apples, pears and table grapes to the European Union. Furthermore, the report encourages discussion between Australian and overseas authorities on the Queensland fruit fly host status of many products. Negotiation on these could realise opportunities in a number of areas:

- Japan—for lemons, limes, grapes, olives, cucumbers, marrow, pumpkin, squash, zucchini, beans and eggplant
- Taiwan—for lemons, limes, grapes, olives, cucumbers, rockmelons, honeydew melons, watermelons, pumpkin, squash, zucchini, beans and eggplant
- Korea—for lemons and limes
- the United States—for lemons, limes, grapes, cucumbers, pumpkin, squash, zucchini, eggplant and blueberries.

Approved organic disinfestation methods include heat and cold treatments and controlled atmosphere.

Market access for Australian horticultural produce is negotiated by the Horticultural Market Access Committee, made up of representatives of Horticulture Australia Limited (which manages the group), Biosecurity Australia, the Australian Quarantine and Inspection Service, the Department of Foreign Affairs and Trade, the Australian Horticultural Exporters Association, the Horticultural Export Consultative Committee, and the National Horticultural Research Network. The Horticultural Market Access Committee assesses identified horticultural products for their market access priority status into an identified market. Growers or other members of the supply chain can make applications for market access consideration. Applicants should complete a market access proposal form, available on the Horticulture Australia website <http://www.horticulture.com.au> or from the National Horticultural Market Access Coordinator.



Appendices

Appendix A Sources of information and other contacts

A.1 AQIS-approved certifying organisations

Australian Certified Organic
Post Office Box 530
L1 766 Gympie Rd
Chermside Qld 4032
Phone: 07 3350 5716
Fax: 07 3350 5996
Email: info@bfa.com.au
Web: http://www.australianorganic.com.au/

AUS-QUAL
Post Office Box 3175
9 Buchanan Street
South Brisbane Qld 4101
Phone: 0 7 3361 9200
Free Call: 1800 630 890
Fax: 0 7 3361 9222
Email: ausqual@ausqual.com.au
Web:http://www.ausqual.com.au

Bio-Dynamic Research Institute
Post Office
Powelltown Vic 3797
Phone: 03 5966 7333
Fax: 03 5966 7433

National Association for Sustainable
Agriculture (Australia) Ltd
PO Box 768
Stirling SA 5152
Phone: 08 8370 8455
Fax: 08 8370 8381
Email: enquiries@nasaa.com.au
Web: http://www.nasaa.com.au

Organic Food Chain
PO Box 2390
Toowoomba Qld 4350
Phone: 07 4637 2600
Fax: 07 4696 7689
Email: organicfoodchain@hotmail.com
Web: http://www.organicfoodchain.com.au/

Tasmanian Organic Dynamic Producers
Phone: 03 6363 5162
PO Box 434
Fax: 03 6363 5162
Mowbray Heights Tas 7248
Email: juliepage001@yahoo.com.au

Safe Food Production Queensland
Spring Hill Qld 4004
55 McLachlan St
Fortitude Valley Qld 4004
Contact: Phil Pond
Phone: 07 3253 9800
Free Call: 1800 300 815
Fax: 07 3253 9824
Email: info@safefood.qld.gov.au
Web: http://www.safefood.qld.gov.au/home.html

A.2 Australian organic industry

Organic Federation of Australia
P.O.Box 369,
Bellingen NSW 2454
Andre Leu, Chair
Phone: 07 4098 7610
Mobile: 0400 075 869
Email: chair@ofa.org.au
Website: http://www.ofa.org.au/

A.3 Export requirements

Australian Quarantine and Inspection Service
Program Management and Operations
Phone: 02 6271 6638
Policy and Market Access
Phone: 02 6272 3509
Fax: 02 6272 3238
Email organic@aqis.gov.au

A.4 NSW and ACT organic and bio-dynamic groups

Henry Doubleday Research Association of Australia
PO Box 442
Richmond NSW 2753
Phone: 02 4567 8424

Bio-Dynamic Agriculture Australia
PO Box 54
Bellingen NSW 2454
Phone: 02 6655 0566

Natural Produce Network
c/- Sam Statham
Rosnay Organic Farms
Canowindra NSW 2804
Phone: 02 6344 3215

Tweed Richmond Organic Producers Organisation
PO Box 5076
East Lismore NSW 2480
Phone: 02 6663 5224

Northern Rivers Biodynamic Group
Ambrosia Farm
Lot 6 English's Road
Upper Coopers Creek NSW 2480
Phone: 02 6688 2003

Sapphire Coast Producers Association
PO Box 1054
Bega NSW 2550
Phone: 02 6492 0161

Riverina Organic Farmers Organisation
c/- Judy Brennan
Clifton
Brocklesby NSW 2642
Phone: 02 6029 4237

Floodplains Organic Growers Group
c/- Frank Old
Balranald NSW 2715
Phone: 03 5020 1770

Hunter Organic Growers Group and the Hunter Biodynamic Group
39 A Dunns ck Rd
Dunns Ck NSW 2320
Phone: 02 4938 5308

Canberra Organic Growers Society Inc.
Elizabeth Palmer
PO Box 347
Dickson ACT 2602
Phone: 02 6248 8004

Coffs Regional Organic Producers Organisation
PO Box 363
Coffs Harbour NSW 2450
(02) 6651 1770

Regional groups in other States and Territories are listed on the Web at: < http://www.organicfooddirectory.com.au/reg-grow-grps.php>

A.5 Diagnostic and analytical services

NSW Department of Primary Industries diagnostic and analytical laboratories are located at Lismore, Wollongbar, Menangle, Orange and Wagga Wagga, supporting the department's research and extension programs. The laboratories also provide commercial services to industry and the public, including tests for agricultural water, animal disease, soil fertility, plant nutrition, chemical residues, and insect and plant pathogen identification. For further details, see <http://www.agric.nsw.gov.au/reader/das-laboratory>.

For soil biological assessment, the following organisation also provides services:

Soil Foodweb Institute Pty Ltd
1 Crawford Rd
East Lismore NSW 2480
Phone: 02 6622 5150
Fax: 02 6622 5170
Email: info@soilfoodweb.com
Web: http://www.soilfoodweb.com

A.6 Consultants

Tim Marshall
PO Box 207
Stirling SA 5152
Phone/fax: 08 83391250
Mobile: 0412473230
Email: timmar@box.net.au

John Melville
Bioterm
Mobile: 0417 662 709
Email: johnwm@bigpond.net.au

Adam Willson
Soil Systems
267 Oxley Road
Graceville Qld 4075
Phone: 07 3716 0688
Fax: 07 3716 0677

Janie McClure
Organics for Rural Australia
Phone: 03 9819 2224
Website: http://www.ruralorg.com.au

NASAA consultants

Steven David
Organic Farming Systems
PO Box 419
Cottesloe WA 6911
Phone: 08 9384 3789
Fax: 08 9384 3379
Email: admin@organicfarming.com.au
Web: http://www.organicfarming.com.au

Kenneth Scott
Piber Pastoral Company
Piber
Roma Qld 4455
Phone/Fax: 07 4623 0213
Email: piber@ripmet.com.au
Web: http://www.maranoa.org.au/kenscott

A.7 Institutional support

Universities, colleges and TAFE offering courses relevant to organic agriculture

Charles Sturt University
Leeds Parade
PO Box 883
Orange NSW 2800
Phone: 1800 334 733
Email: inquiry@csu.edu.au
Website: www.csu.edu.au/campus/orange

Relevant courses offered:

- Master of Sustainable Agriculture
- Graduate Diploma in Sustainable Agriculture
- Graduate Certificate in Sustainable Agriculture
- Bachelor of Land Management (Ecological Agriculture)
- Advanced Diploma of Land Management (Ecological Agriculture)

Murrumbidgee Rural Studies Centre
Yanco Agricultural Institute
Yanco NSW 2703
Phone: 02 6951 2696

and

CB Alexander Agricultural College Tocal
Paterson NSW 2421
Phone: 02 4939 8888

Relevant courses offered:

- organic and biodynamic courses in conjunction with local groups

TAFE NSW Web: http://www.tafensw.edu.au

Relevant courses offered:

- Organic Farming nos. 652 and 653

Government

- NSW Department of Primary Industries:

  Robyn Neeson, Yanco Agricultural Institute

  Phone: 02 6951 2611

  Karen O'Malley, Bathurst Agricultural Research Station

  Phone: 02 6330 1200

  Scott Seaman, Bathurst Agricultural Research Station

  Phone: 02 6330 1209

- Department of Natural Resources and Environment, Victoria:

  Viv Burnett Agriculture Victoria, Rutherglen
  Phone: 02 6030 4500

- Tasmanian Department of Primary Industries and Water (DPIW)

  Louise Mills, PO Box 44
  HOBART TAS 7001
  Phone: 03 6233 4038

- Queensland Department of Primary Industries and Fisheries
  Phone: 13 25 23
- Primary Industries and Resources South Australia
  http://www.safoodcentre.com/industry/pages/sector/
- Northern Territory Department of Business, Industry and Resource Management
  http://www.primaryindustry.nt.gov.au/
- Australian Government Department of Agriculture, Fisheries and Forestry
  http://www.affa.gov.au/content/output.cfm?ObjectID=D2C48F86-BA1A-11A1-A2200060A1B01861
- Australian Quarantine and Inspection Service
  Ian Lyall, Manager, Organic and Biodynamic Program—phone 02 6271 6638 or 0417 667 040

NSW government assistance

Department of State and Regional Development

Website: <http://www.business.nsw.gov.au/>
Office locations: <http://www.business.nsw.gov.au/help.asp?cid=251>

Primex

Primex is the international export marketing arm of NSW Department of Primary Industries, providing international access to the highest quality commodities of New South Wales. Primex works closely with local producers and international buyers to encourage partnerships in a broad range of commodities.

Primex, NSW Department of Primary Industries
PO Box K220
Haymarket NSW 1240
Phone: 02 8289 3999
Email: agsell@agric.nsw.gov.au

Federal government assistance

The New Industries Development Program and Agribiz

The New Industries Development Program helps people in the agricultural, processed food, fisheries and forestry industries turn innovative business ideas into competitive, profitable and sustainable commercial ventures. Agribiz encourages and supports Australian agribusinesses as they commercialise new products, services and technologies. For more information check the website < http://www.daff.gov.au/agriculture-food/nidp-agribiz >.

Austrade and TradeStart

Austrade and TradeStart offer a package of free services designed to help small and medium-sized Australian companies develop their business overseas and make their first export sale. The TradeStart program gives Australian businesses the best possible start to exporting, providing a wide range of free services to new exporters, including advice and information about getting into exporting, export coaching, and assistance on the ground in foreign markets.

To find out more about TradeStart and what the export advisors and Austrade's international network offer, go to < http://www.austrade.gov.au/Home3618/default.aspx >.

Farmer information group

Kondinin Group
8 Fitzhardinge St
Wagga Wagga NSW 2650
Phone: 02 6921 4047
Web: http://www.kondinin.com.au

A.8Journals and newsletters

Acres Australia. The national newspaper of sustainable agriculture. Published monthly. Free Call: 1800 801 467. Available through newsagents. Web: < http://www.acresaustralia.com.au/index.php?page=home>

Acres USA®. Subscribe by email <info@acresusa.com>.n Web: < http://www.acresusa.com/magazines/magazine.htm>

Going Organic. Official newsletter of the Tweed Richmond Organic Producers Organisation. Phone the editor, Wendy Seabrook—02 6682 8148.

News Leaf. Journal of the Biodynamic Agriculture Australia. Phone : 02 6655 0566.

Canberra Organic. Quarterly publication of the Canberra Organic Growers Society. Phone: 02 6258 2811

NASAA Bulletin. Official Journal of the National Association of Sustainable Agriculture Australia. Phone NASAA—08 8370 8455.

Australian Organic Journal. Produced by Biological Farmers of Australia. Contact BFA—07 3350 5716.

The Producer. Official journal of the Sapphire Coast Producers Association (bi-monthly)—02 6492 0161.

A.9 Useful websites

http://www.attra.org

http://www.goodbugs.org.au

http://www.anbp.org

http://ipmwww.ncsu.edu/biocontrol/biocontrol.html

http://www.biocontrol.ucr.edu/

http://www.nysaes.cornell.edu/ent/biocontrol/

http://www.nysaes.cornell.edu/recommends/

http://www.bioresources.com.au

http://www.bugsforbugs.com.au

http://www.ipm.iastate.edu/

http://www.IPMnet.org

http://www.IPM.ucdavis.edu

http://ipmworld.umn.edu

http://www.nysipm.cornell.edu

http://vegedge.umn.edu/

Australian government websites

NSW Department of Primary Industries— http://www.dpi.nsw.gov.au/

Queensland Department of Primary Industries and Fisheries— http://www.dpi.qld.gov.au/cps/rde/xchg/dpi/hs.xsl/home_ENA_HTML.htm

Victorian Department of Natural resources and Environment—http://www.dpi.vic.gov.au/dpi/index.htm

Agriculture Western Australia—http://www.agric.wa.gov.au/

Northern Territory Department of Primary Industries and Fisheries—http://www.nt.gov.au/dpifm/Primary_Industry/

Tasmanian Department of Primary Industries and Fisheries— http://www.dpiw.tas.gov.au/inter.nsf/Home/1?Open

South Australian Department of Primary Industries and Resources—http://www.pir.sa.gov.au/agwine

Department of Agriculture, Forestry and Fisheries—http://www.daff.gov.au/

Other websites

Agriculture Network Information Centre (US site)—http://www.agnic.org/

Avcare, National Association for Crop Protection & Animal Health—http://www.avcare.org.au

Bureau of Meteorology—http://www.bom.gov.au/

Horticulture Australia—http://www.horticulture.com.au

Heliothis development model—http://www.uq.edu.au/~uqwroche/gentime/

Markets, Brisbane—http://www.brisbanemarkets.com.au/

Markets, Melbourne—http://www.melbournemarkets.com.au/

Markets, Sydney—http://www.sydneymarkets.com.au/

Vegetable Research and Information, University of California—http://www.vric.ucdavis.edu/

http://afsic.nal.usda.gov/nal_display/index.php?info_center=2&tax_level=1

http://www.fao.org/organicag/

http://www.organic-research.com/

http://www.ofa.org.au

http://www.bfa.com.au

http://www.nasaa.com.au

http://www.soilfoodweb.com/

http://www.ofrf.org/

http://www.soilassociation.org/web/sa/saweb.nsf/home/index.html

http://www.newcrops.uq.edu.au/newslett/ncnl1112.htm

http://www.farmerfred.com/plants_that_attract_benefi.html

http://www.organic-europe.net/

http://www.ams.usda.gov/nop/indexIE.htm

http://www.organicherbs.org/Main.html

http://www.mda.state.mn.us/esap/organic/default.htm

http://www.organicstandard.com/

http://www.farmersmarkets.org.au/

http://www.cogs.asn.au/

http://www.nal.usda.gov/afsic/AFSIC_pubs/findinfo.htm

A.10 Other contacts

Integrated pest management

Australian Entomological Supplies
Supplier of hand lenses, sticky traps, and other equipment
Phone: 02 6684 7650
Web: http://www.entosupplies.com.au

Commercial insectaries

Australasian Biological Control (Association of Commercial Insectaries)
http://www.goodbugs.org.au

Beneficial Bug Co.
PO Box 436
Richmond NSW 2753
Phone: 02 4570 1331
Fax: 02 4578 3979
Email: Info@beneficialbugs.com.au
Web: http://www.beneficialbugs.com.au
(predatory mites, Phytoseiulus persimillis)

Bugs for Bugs
Bowen St
Mundubbera Qld 4626
Phone: 07 4165 4663
Fax: 07 4165 4626
Email: info@bugsforbugs.com.au
Web: http://www.bugsforbugs.com.au
(*Aphytis* spp., *Chilocorus* beetles, *Cryptolemus* beetles, green lacewings, trichogramma wasps)

Bio-Protection
PO Box 384
Kilmore Vic 3764

Phone: 03 5781 0033
Fax: 03 5781 0044
Email: rcoy@hyperlink.com.au
(predatory mites—*Phytoseiulus persimillis*)

BioResources
PO Box 578
Samford Qld 4520
Phone: 07 3289 4919
Fax: 07 3289 4918
Email: richard@bioresources.com.au
Web: http://www.bioresources.com.au
(*Orgilus lepidus* and trichogramma)

Biological Services
PO Box 501
Loxton SA 5333
Phone: 08 8584 6977
Fax: 08 8584 5057
Email: fruitdrs@sa.ozland.net.au

Web: http://www.biologicalservices.com.au/
(*Aphytis* spp., *Encarsia formosa, Hypoaspis miles, Typhlodromus occidentalis*)

BioWorks Pty Ltd
PO Box 203
Nambucca Heads NSW 2448
Phone: (02) 6568 3555
E-mail: bioworks@optusnet.com.au
(*Phytoseiulus persimilis*)

Ecogrow Australia Pty Ltd
P.O. Box 7657
Bondi Beach NSW 2026
Phone: 0417 242 222
Fax: 02 9327 4610
Email: info@ecogrow.com.au
Web: http://www.ecogrow.com.au
(entomopathogenic nematodes)

Horticultural Crop Monitoring
P.O. Box 3725
Caloundra Qld 4662.
Phone: (07) 5439 6077
Fax: (07) 5439 6088
Email: pjones@hotkey.net.au
Web: http:// www.biomites.com.au
(predatory mites—*Phytoseiulus persimillis*)

IPM Technologies
PO Box 560
Hurstbridge Vic 3099
Phone: 03 9710 1554
Fax: 03 9710 1354
Email: ipmtechnologies@bigpond.com
Web: http:// www.ipmtechnologies.com.au
(*Orgilus lepidus*)

Manchil IPM Services
1/17 Batavia Place Kallaroo
Western Australia 6025
Mobile: 0403 727 252
email: lachlanchilman@hotmail.com
web: http://www.manchilipmservices.com.au
(*Phytoseiulus persimilis*)

BioForce Ltd
PO Box 81
Pukekohe, NZ
Phone: 64 9 294 8973
Fax: 64 9 294 8978
Email: john.thompson@xtra.co.nz
(*Aphidius colemani, Bomus terrestris, Encarsia formosa, Neoseilus cucumeris, Phytoseiulus persimillis*)

Pheromones

Dunluce International
Michael MacQuillan
PO Box 922
St Ives NSW 2075
Phone/Fax: 02 9983 1776

(*Helicoverpa armigera* and *H. punctigera* lures and Agrisense® funnel traps)

Pesticide registration information

Australian Pesticides and Veterinary Medicines Authority—http://www.APVMA.gov.au

INFO Pest CD
Animal and Plant Health Service
Department of Primary Industries and Fisheries
GPO Box 46
Brisbane Qld 4001
Phone: 07 3239 3967
Fax: 07 3211 3293
Email: infopest@dpi.qld.gov.au
Web: http://www.dpi.qld.gov.au/cps/rde/xchg/dpi/hs.xsl/4790_4885_ENA_HTML.htm

PestChem manuals
Centre for Pesticide and Application Safety
University of Queensland
Gatton College
Gatton Qld 4343
Phone: 07 5460 1293

Crop Protection Approvals Ltd
Suite 5, Moonee Ponds Business Centre
5 Everage Street
Moonee Ponds Vic 3039
Phone: 03 8371 0001
Fax: 03 8375 7552
Email: Cpa@cpaltd.com.au

Input and equipment suppliers

Organically certified pest and disease control products

Organic Crop Protectants
42 Halloran St
Lillyfield NSW 2040
Contact: Gary Leeson
Free Call: 1800 634 204
Web: http://www.ocp.com.au

Composted cow manure

Rivcow Environmental Pty Ltd
PO Box 135
Yanco NSW 2703
Phone: 02 6953 5985
Mobile: 0419 748 269
Fax: 02 6953 5986
Email: sales@rivcow.com.au
Web: http://www.rivcow.com.au/Default.asp

Small farm hand tools and electric net (livestock and poultry) fencing

Gundaroo Tiller
Joyce Wilkie and Michael Plane
Allsun Farm
Gundaroo NSW 2620
Phone: 02 6236 8173
Fax: 02 9383 8894
Email: GT@allsun.com.au
Web: http://www.allsun.com.au/

Weed cultivation and soil management equipment

WeedFix® cultivator
Fix Engineering
Wheeles Hill Rd
RMB 4801
Daylesford Vic 3460
Phone: 03 5348 2669
Mobile: 0418 508 573

Sustainable Agricultural Machinery Developments Pty. Ltd
3 Bradford Street, Wodonga,
Victoria 3690. Australia.
Phone: (02) 6056 2844
Fax: (02) 6056 2994
Email: samsales@samd.com.au
Postal: P.O. BOX 1321 Wodonga,
Victoria 3689.

A.11 Other contacts, by chapter

Chapter 6

Murrumbidgee Rural Studies Centre
Yanco NSW 2703
Phone: 02 6951 2611

National Organic Auditor training workshops
Biological Farmers of Australia
Phone: 07 3350 5716
Fax: 07 3350 5996
Email: info@bfa.com.au

Independent Organic Inspector Association Organic Training workshops
Contact NASAA office
Phone: 08 8370 8455

Genevieve Carruthers
Environmental Management Systems Specialist
NSW Department of Primary Industries
Wollongbar Agricultural Institute
Wollongbar NSW 2477
Phone: 02 6626 1237

Joseph Ekman
Extension Horticulturist, Quality Assurance
NSW Department of Primary Industries
National Centre for Greenhouse Horticulture
Locked Bag 26
Gosford NSW 2250
Phone: 02 4348 1900

Marketing advice and promotions

Primex
Level 6, 201 Elizabeth Street
Sydney NSW 2000
Phone: 02 8289 3999

Catriona Macmillan
Heaven & Earth Systems Pty Ltd
PO Box 3335
Tamarama NSW 2026
Phone: 02 9365 7668
Fax: 02 9365 7828

Packaging and labelling laws

NSW Office of Fair Trading
PO Box 972
Parramatta 2124
Local Call: 13 32 20
Fax: 02 9758 2691
Web: http://www.fairtrading.nsw.gov.au/default.html

NSW Food Authority
PO Box 6682
Silverwater NSW 1811
Local Call: 1300 552 406
Fax: 02 9647 0026
Email: contact@foodauthority.nsw.gov.au
Web: http://www.foodauthority.nsw.gov.au

Trade Marks Office
PO Box 200
Woden ACT 2606
Phone: 1300 651 010
Web: http://www.ipaustralia.gov.au/about/index.shtml

Appendix B Farming inputs

The following information comes from the National Standard for Organic and Biodynamic Produce (Edition 3.3, 1 July 2007. AQIS, Canberra.)

Requirements for use

General principles

i. Where inputs are required they should be used with care and with the knowledge that even permitted inputs can be subject to misuse and may alter the soil and/or water ecosystems or the farming environment.

ii. Use of any product has the potential to introduce unwanted residues and contaminants.

Standards

1. A developed organic or biodynamic farm must operate within a closed input system to the maximum extent possible.
2. External farming inputs must be kept to a minimum and applied only on an 'as needs' basis.
3. Inputs must not be used as a permanent measure to support a poorly designed or badly managed system. Non-essential use of inputs is counter to organic and biodynamic farming principles. The approved certifying organisation must give approval for their ongoing use.
4. The following lists are subject to review, and inclusion of a material does not imply that it is safe in all circumstances. Any additions or changes to the lists will be made where it can be demonstrated that they satisfy the requirements of this Standard.
5. Liquid preparations, including products of the sea must be used with care as some preparations can be easily applied in concentrated forms and in high quantities.
6. The use of trace elements must be on the basis of a demonstrated deficiency.
7. Use of any input must be based on an assessment of need and with knowledge of the origin and/or analyses of the material for contaminants.
8. The use of any materials/inputs will be recorded in the farm diary or logbook and repeated use must be justifiable.
9. Federal, state/territory and local laws must be adhered to at all times …

Permitted materials for soil fertilising and conditioning

Substances	Specific conditions/ restrictions
Animal manures	Application must be composted or followed by at least two green manure crops in cropping system.
Blood and bone, fish meal, hoof and horn meal, or other waste products from livestock processing	Following application, uptake of such products by livestock does not form part of the animals diet.
Compost	Should be produced in accordance with Australian Standard 4454-1999 or recognised equivalent system.
Minerals and trace elements from natural sources, including: • calcium (dolomite, gypsum, lime) • clay (bentonite, kaolin, attapulgite) • magnesium • phosphate (rock phosphate, phosphatic guano) • potash (rock and sulphate potash) • elemental sulphur	Must not be chemically treated to promote water solubility
Epson salt—magnesium sulphate)	None
Microbiological, biological and botanical preparations	Products derived from genetic modification technology are prohibited
Mined carbon-based products	Peat to be used for plant propagation only
Naturally occurring biological organisms (e.g. worms) and their by-products	None
Plant by-products	From chemically untreated sources only
Perlite	For potting/seedling mixes only
Sawdust, bark and wood waste	From chemically untreated sources only
Seaweed or algae preparations	None
Straw	From chemically untreated sources only
Trace elements and natural chelates, (e.g. ligno) sulphonates and those using the natural chelating agents (e.g. citric, maleic and other di-/tri-acids)	Not synthetically chelated elements
Vermiculite	For use in potting/seedling mixes only
Wood ash	From chemically untreated sources only
Zeolites	None

Permitted materials for plant pest and disease control

Where wetting agents are required, caution needs to be exercised with commercial formulations as these may contain substances prohibited under this Standard. Acceptable wetting agents include some seaweed products, plant products (including oils) and natural soaps.

Plant pest control

Substances	Specific conditions/ restrictions
Ayurvedic preparations	None
Baits for fruit fly	Substances as required by regulation. Baits must be fully enclosed within traps.
Boric acid	None
Biological controls	Naturally occurring cultured organisms (e.g. Bacillus thuringiensis)
Diatomaceous earth and naturally occurring chitin products	None
Essential oils, plant oils and extracts	None
Homeopathic preparations	None
Hydrogen Peroxide	None
Iron (III) phosphate	None
Light mineral oils, such as paraffin	None
Lime	None
Natural acids (e.g. vinegar)	None
Natural plant extracts excluding tobacco	Obtained by infusion and made by the farmer without additional concentration
Pheromones	None
Potassium permanganate	None
Pyrethrum	Extracted from Chrysanthemum cinerariaefolium
Quassia	Extracted from Quassia armara
Rotenone	Extracted from Derris elliptica
Ryania	Extracted from Ryania speciosa
Seaweed, seaweed meal, seaweed extracts	None
Sea salts and salty water	None
Sodium bicarbonate	None
Sterilised insect males	Need recognised by certification organisation where other controls are not available.
Stone meal	None
Vegetable oils	None

Plant disease control

Substances	Specific conditions/ restrictions
Ayurvedic preparations	None
Biological controls	Naturally occurring cultured organisms only
Copper (e.g. Bordeaux and Burgundy mixture)	Hydroxide is the preferred form, Bordeaux only on dormant tissue. Annual copper application must be less than 8kg/ha.
Essential oils, plant oils and extracts	None
Granulose virus preparations	Need recognised by certification organisation.
Homeopathic preparations	None
Light mineral oils (such as paraffin)	None
Lime	None
Lime-sulphur	None
Natural plant extracts excluding tobacco	Obtained by infusion and/or made by the farmer without additional concentration
Potassium permanganate	None
Potassium soap (soft soap)	None
Propolis	None
Seaweed, seaweed meal, seaweed extracts	None
Sea salts and salty water	None
Skim milk or skim milk powder	None
Sodium bicarbonate	None
Sodium silicate (water-glass)	None
Sulphur	In wettable or dry form only
Vegetable oils	None
Vinegar	None

Permitted materials for livestock pest and disease control

Where wetting agents are required, caution needs to be exercised with commercial formulations as these may contain substances prohibited under this Standard. Acceptable wetting agents include some seaweed products, plant products (including oils) and natural soaps.

Livestock pest control

Substances	Specific conditions/restrictions
Ayurvedic preparations	None
Biological controls	Naturally occurring organisms and cultured organisms
Boric acid	None
Clay	None
Diatomaceous earth	None
Essential oils, plant oils and extracts	None
Garlic oil, garlic extract or crushed garlic	None
Homeopathic preparations	None
Hydrogen peroxide	None
Natural plant extracts obtained by infusion	Excluding tobacco
Magnesium sulphate (Epsom salts)	None
Methylated spirits	None
Monosodium fluorosilicate	None
Potassium permanganate	None
Pyrethrum	Extracted from *Chrysanthemum cinerariaefolium*
Quassia	Extracted from *Quassia armara*
Rotenone	Extracted from *Derris elliptica*
Sea salts and salty water	None
Seaweed, seaweed meal, seaweed extracts	None
Sodium Bicarbonate	None
Sulphur	None
Vinegar (e.g. cider)	None

Livestock disease control

Substances	Specific conditions/ restrictions
Ayurvedic preparations	None
Calcium salts	None
Charcoal	None
Clay	None
Copper sulphate	None
Diatomaceous earth and naturally occurring chitin products	None
Essential oils, plant oils and extracts	None
Homeopathic preparations	None
Hydrogen peroxide	None
Natural plant extracts obtained by infusion	Excluding tobacco
Magnesium sulphate (Epsom salts)	None
Methylated spirits	None
Potassium permanganate	None
Sea salts and salty water	None
Seaweed, seaweed meal, seaweed extracts	None
Sodium bicarbonate	None
Trace elements	To correct identified deficiencies only
Vaccines	May be used only for a specific disease, which is known to exist on the organic farm or neighbouring farms and which threatens livestock health and which cannot be effectively controlled by other management practices. Vaccines must not contain genetically modified ingredients or by-products.
Vitamins	Natural sources only
Vinegar (e.g. cider)	None
Zinc sulphate	None

Substances permitted for sanitation, storage and handling

1. Operators will select cleaners, sanitisers, and disinfectants based on avoidance of residual contamination, rapid biodegradability, low toxicity, worker safety, and a life-cycle impact of their manufacture, use, and disposal.
2. Endocrine disrupting, ozone depleting, and trihalomethane-forming compounds used in sanitation chemicals are prohibited.
3. Substances Permitted as Sanitation treatments include:
   - Alkali carbonates
   - Bleach (not to exceed 10% solution)
   - Biodegradable detergents (e.g. low in phosphate and rapidly degradable)
   - Caustic potash and caustic soda
   - Ethyl alcohol
   - Hydrogen peroxide
   - Iodine (non-elemental, not to exceed 5% solution e.g. iodophors)
   - Lime
   - Lye
   - Natural acids (e.g. vinegar, lactic, phosphoric)
   - Potassium permanganate (not to exceed 1% solution)
   - Soaps
   - Sodium bicarbonate
   - Sodium borate
   - Isopropyl alcohol
4. The use of any of the above substances will be followed by a thorough rinse of the area/equipment using potable water.
5. Cleaning and sanitising chemicals will be used and stored in such a manner so as to avoid cross-contamination to organic and bio-dynamic produce.

Substances permitted as post-harvest/storage treatments

Treatments	Substances/conditions
Controlled atmosphere	Carbon dioxide Oxygen Nitrogen Ozone
Peracetic acid	Approval for use required
Ethylene gas	Ripening of bananas only)
Pest control	Physical barriers Temperature control Diatomaceous earth Rodenticides* Sticky boards Biological controls Electric barriers or grids Sound Light
Waxing of citrus fruit	Export only—using natural wax

* *Must be enclosed outside processing area and used only where other methods have proved ineffective. Containers must be positioned so that there is no potential for contamination with products complying with this Standard. Containers must be inspected regularly and dead rodents removed. The operator must maintain records on volume and use of rodenticides.*

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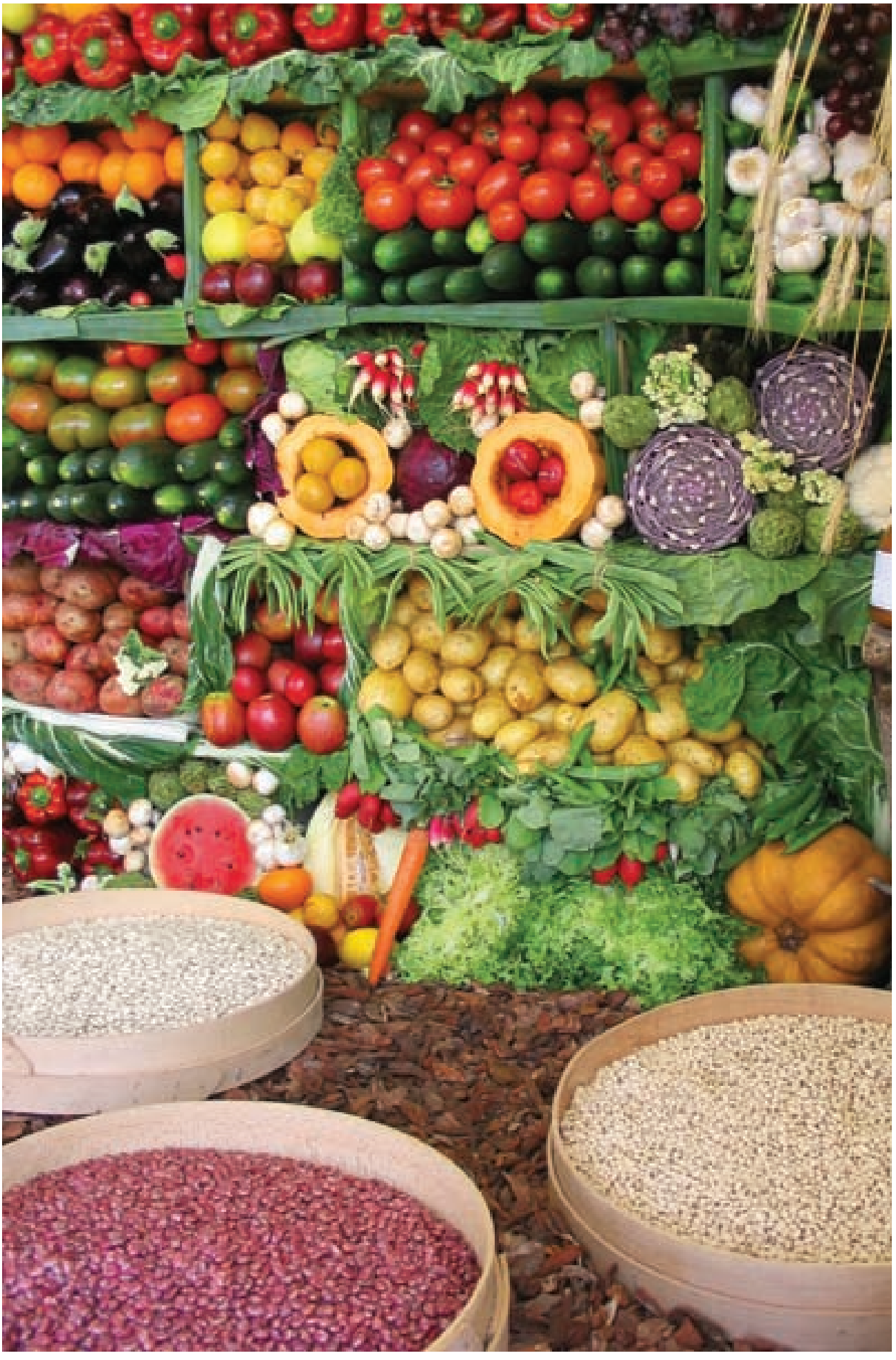
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Going Organic

Organic Vegetable Production

A conversion package

By Robyn Neeson

Publication no. 07/137. Project no. DAN-188A

This information is for producers wishing to convert to organic production and for producers already involved in organic production but keen to diversify their production. It provides a framework for organic conversion and diversification and suggests possible strategies and pathways for moving forward.

This valuable information will help make the transition to organic production or to diversified organic production a smooth one.

Organic products are the fastest growing food sector worldwide. Growth of new farms, products and consumers has been steadily increasing over the last 20 years. In the last 10 years the rate of growth has consistently increased in all of the advanced economies.

Market analysts forecast annual growth rates between 10% and 30% around the world. The United States Department of Agriculture expects the organic industry to be worth US$100 billion by 2010 in America, Europe and Japan.

Major international food corporations are developing organic product lines.

The Australian organic sector is worth between $250 - $400 million per annum at retail level and demand outstrips supply. Domestic production is increasing at between 6 -15% per annum and consumption is growing at between 25-40%—the balance is imported. Australia is one of the world's leading grain exporters but organic grain is imported to meet the shortfall in production. Rising domestic and overseas demand for Australian organic products is prompting more conventional farmers and processors to consider and adopt organic systems.

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A GUIDE TO MORE THAN 350 PESTS OF HOME, GARDEN, FIELD, AND FOREST



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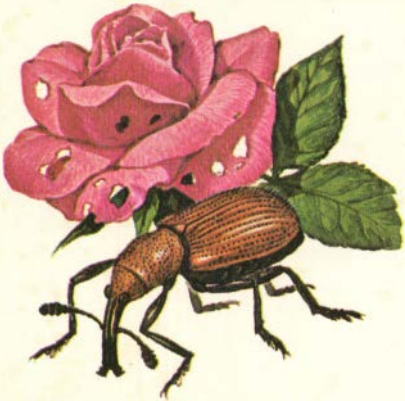
INSECT PESTS

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Under the Editorship of
HERBERT S. ZIM, Ph.D.

Illustrated by
NICHOLAS STREKALOVSKY



A GOLDEN NATURE GUIDE

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FOREWORD

Despite modern technology, man still depends wholly on the products of nature for survival. Hence the battle to control insect pests is a never-ending necessity.

This book describes more than 350 pests that are found in middle North America. The illustrations, skillfully rendered by Nicholas Strekalovsky, will help identify the pest, its life stages, and the kind of damage it does. The best times and methods of control are suggested, but as these vary locally, get the advice of an entomologist or an agricultural agent before attempting major controls. The pest groupings in this book are based on where usual damage occurs. At times when they are abundant, however, pests become less selective. A field pest then, for example, may become bothersome in gardens. Insecticides are the best means to get immediate results, but remember: insecticides are poisonous. Follow directions and heed all precautions on the label.

A number of people gave advice and assistance in the preparation of this book. These included Dr. J. F. Gates Clarke and his staff at the U.S. National Museum. Also of great help were Robert H. Nelson and members of the Entomological Society of America. Dr. Jean L. Laffoon was especially helpful, as were Dr. George Anastos, Dr. R. M. Baranowski, Dr. Ralph Crabill, Dr. Richard L. Doutt, Dr. Richard C. Froeschner, Dr. Herbert W. Levi, Dr. Franklin B. Lewis, and Dr. Howard V. Weems.

G. S. F.

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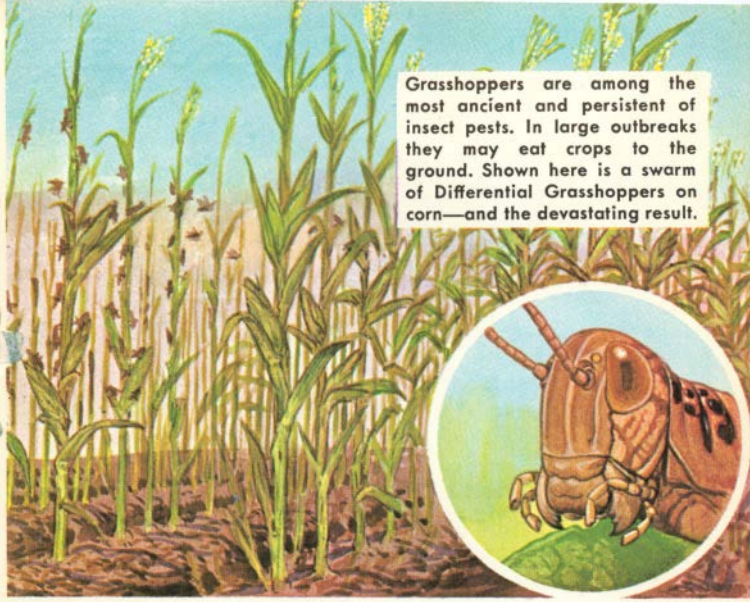




INTRODUCTION TO INSECT PESTS

Insects exist in enormous numbers. The average insect population per square mile is estimated to be equal to the total world population of people, and in severe outbreaks a pest species far exceeds its normal numbers. In one fly infestation, experts estimated 15,000 flies per cow. Billions of hungry grasshoppers may darken the sky and devour all vegetation in their path.

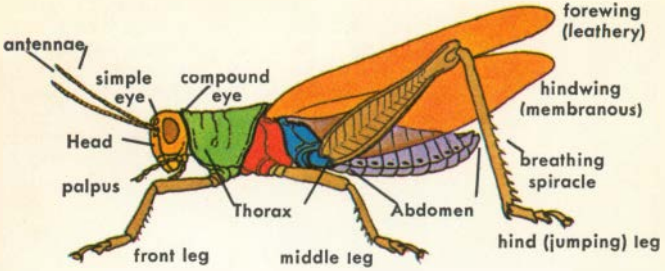
Insect destruction of crops in the United States ranges from 4 billion to 15 billion dollars annually. Damage to cotton by one insect, the Boll Weevil, amounts to more than 300 million dollars a year. Termites consume about 100 million dollars' worth of wood structures, while forest insects destroy more wood than do forest fires. Insect damage cancels out the total year's efforts of about one million workers.



Grasshoppers are among the most ancient and persistent of insect pests. In large outbreaks they may eat crops to the ground. Shown here is a swarm of Differential Grasshoppers on corn—and the devastating result.

Fortunately, less than one percent of the nearly one million insect species are pests of man, his domestic animals, and useful plants. Of the 100,000 insect species that occur in the United States, only about 600 are considered serious pests.

Damage done by insect pests is easy to appraise. The value of beneficial species is harder to estimate. Bees, wasps, flies, butterflies, and other insects pollinate flowers that provide us with fruits and vegetables. Honey, wax, and silk are important commercial products obtained from insects. Some insect species are vital links in the food chains of fishes, birds, and other animals. Other insects are parasites or predators of damaging pests or are scavengers of animal and vegetable debris. Control measures used against harmful insects must be weighed carefully to determine the ultimate effect on all living things, including man.



PARTS OF A TYPICAL INSECT

INSECTS AND THEIR CLOSE RELATIVES are arthropods, or "jointed-legged" animals, a large group that includes more than 85 percent of the known species of animals. About 90 percent of all the arthropods are insects. An insect's body has three distinct regions—head, thorax, and abdomen. Attached to its thorax are three pairs of legs, and in most species, two pairs of wings. Its head bears a pair of antennae. This combination of features distinguishes insects (class Insecta) from such closely related land animals as spiders, ticks, mites, centipedes, and millipedes.

The largest groups of insects are called *orders*. Sixteen orders of insects that include important pest species are summarized on page 7, as are the identifying characteristics of the other arthropod classes.

Orders are divided into *families* and the families into *genera* and *species*. An insect's scientific name usually consists of two words, its genus and species. The scientific names of the pests in this book are listed on pages 154–156. The common names used in the text are those approved by the Entomological Society of America.

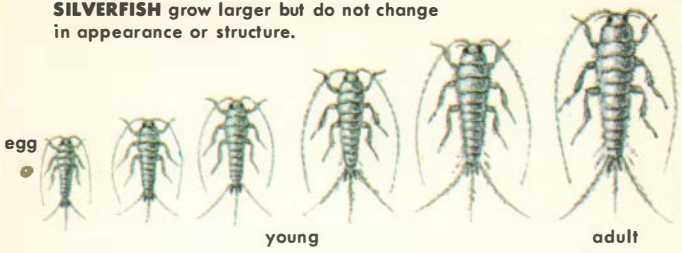
MAJOR ORDERS OF INSECTS

CLASS	NAME OF ORDER	COMMON EXAMPLES	WINGS, MOUTHPARTS
INSECTA	Thysanura	silverfish, firebrats	wingless; chewing
	Collembola	springtails	wingless; chewing
	Orthoptera	grasshoppers, crickets, cockroaches	2 prs. wings or wingless; chewing
	Dermaptera	earwings	2 prs. wings or wingless; chewing
	Isoptera	termites	2 prs. wings or wingless; chewing
	Psocoptera	barklice, booklice	2 prs. wings or wingless; chewing
	Mallophaga	chewing lice	wingless; chewing
	Anoplura	sucking lice	2 prs. wings or wingless; piercing-sucking
	Thysanoptera	thrips	2 prs. wings or wingless; rasping-sucking
	Homoptera	aphids, leafhoppers scales, mealybugs	2 prs. wings or wingless; piercing-sucking
	Hemiptera	bed bugs, stink bugs, chinch bugs	wingless; piercing-sucking
	Coleoptera	beetles, weevils	2 prs. wings or wingless; chewing
	Lepidoptera	moths, butterflies	2 prs. wings; chewing (larvae), sucking, or siphoning (adults)
	Hymenoptera	wasps, bees, ants sawflies	2 prs. wings or wingless; chewing
	Diptera	mosquitoes, flies, gnats	1 pr. wings; chewing (larvae), piercing-sucking, or sponging (adults)
	Siphonaptera	fleas	wingless; chewing (larvae), piercing-sucking (adults)

CLASSES OF OTHER ARTHROPOD PESTS

ARACHNIDA	spiders, ticks, mites, scorpions	4 prs. legs; 2 body regions—cephalothorax and abdomen; no antennae; chewing or sucking mouthparts
CHILOPODA	centipedes	1 pr. of legs per body segment; 1 pr. of antennae; 2 body regions—head, trunk; body flattened; chewing mouthparts
DIPLOPODA	millipedes	2 prs. of legs per apparent body segment; 1 pr. of antennae; 2 body regions—head, trunk; body rounded; chewing mouthparts

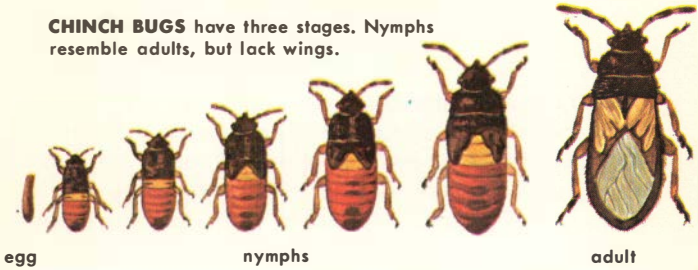
SILVERFISH grow larger but do not change in appearance or structure.



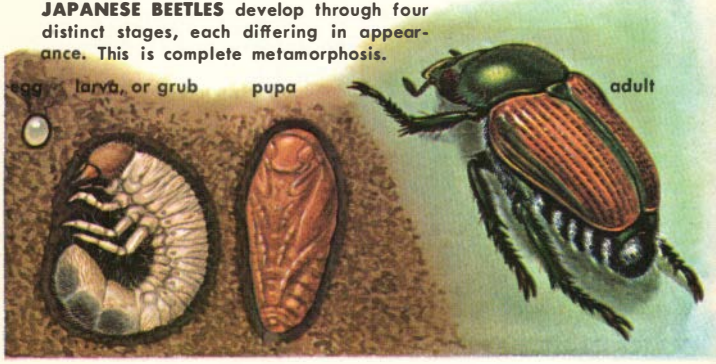
INSECT DEVELOPMENT An insect pest can be controlled most easily at a specific stage of its life history, sometimes not the one in which it does its greatest damage. Destroying the insect's eggs is often the most effective control measure. But to do this you must know where and when the female lays her eggs. Hence life histories are emphasized in this book.

Nymphs are young insects that, as soon as they hatch, resemble miniature adults. If the adult has wings, wing buds soon appear on the nymph's thorax. These grow each time the nymph sheds, or molts, and by the time the insect is mature, the wings are fully developed.

Nymphs are active. They commonly live in the same place and have the same feeding habits as the adults. True bugs, grasshoppers, cockroaches, and lice are among the insects that have a nymph stage. These change (metamorphose) gradually through three developmental stages—egg, nymph, and adult. This type of metamorphosis is called simple. Primitive insects, such as silverfish and springtails, also develop by a simple metamorphosis, but there are almost no changes in their structure as they grow, only an increase in size. Nymphs of some aquatic insects are called naiads; they differ considerably from adults in appearance and habits but change from naiads directly into adults.



CHINCH BUGS have three stages. Nymphs resemble adults, but lack wings.



JAPANESE BEETLES develop through four distinct stages, each differing in appearance. This is complete metamorphosis.

More kinds of insects develop through a complete metamorphosis. The insect changes in appearance and habits from one stage to the next through four distinct stages—egg, larva, pupa, and adult. The egg hatches into a larva, an active, feeding stage. The mature larva forms a pupa, a resting, or nonfeeding, stage from which the insect emerges as an adult. Caterpillars are the crawling larvae of butterflies and moths. They have chewing mouthparts. Some are major pests of plants and stored products. The adults have sucking, or nectar-feeding, mouthparts and never do damage. Maggots are the larvae of flies; grubs, the larvae of beetles.

CONTROLLING INSECTS

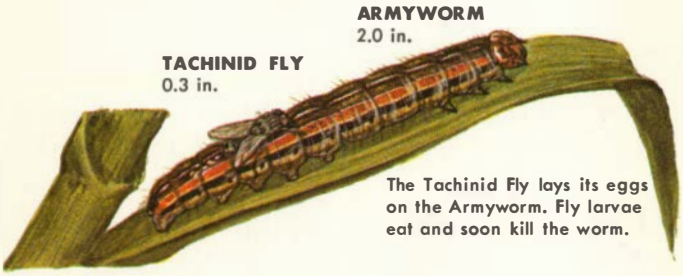
Insects become pests when they damage crops, destroy products, transmit diseases, are annoying, or in other ways conflict with man's needs or interests. In man's continuous battle against insect pests through the centuries, no insect species has ever been eradicated, though some have been reduced in number, at least temporarily. At the same time, other pest species have actually become more abundant and are now a greater problem because man has provided increasingly favorable conditions for them. The modern one-crop system of agriculture often supplies food for an insect pest in large quantity over many square miles. As new crop plants were introduced from other countries, their insect pests often came with them, but not the predatory species that kept the pests under control in their homeland. Some varieties of crops are more susceptible to pests than were the original wild plants, which over the years developed a degree of resistance to insect attack.

NATURAL CONTROLS ordinarily keep insect populations in balance. Weather factors, such as temperature and rainfall, limit the distribution of an insect species, as do such geographic barriers as large bodies of water, deserts, or mountain ranges.

Toads, lizards, frogs, moles, and shrews are among the many animals that feed mainly on insects. Some birds may eat their own weight in insects every day. Predatory insects usually feed on whatever insects are available. Larvae of parasitic insects develop in the eggs, young, or adults of other insects. Virus, fungus, and bacterial diseases also help hold insect populations in check. Man has often upset these natural balances.



Because insect-eating birds tend to eat the most available insects, they are especially helpful in controlling pests in outbreaks.



The Tachinid Fly lays its eggs on the Armyworm. Fly larvae eat and soon kill the worm.

Braconid wasps lay eggs in aphids or other insects. Larvae develop inside.

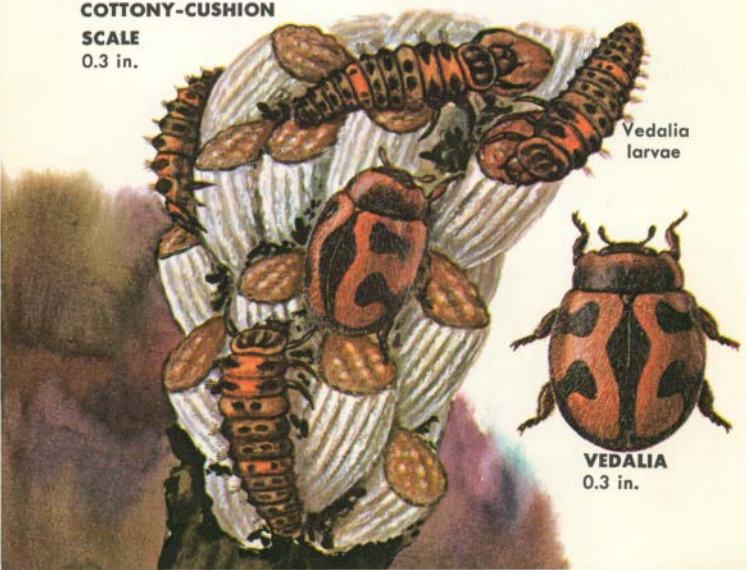


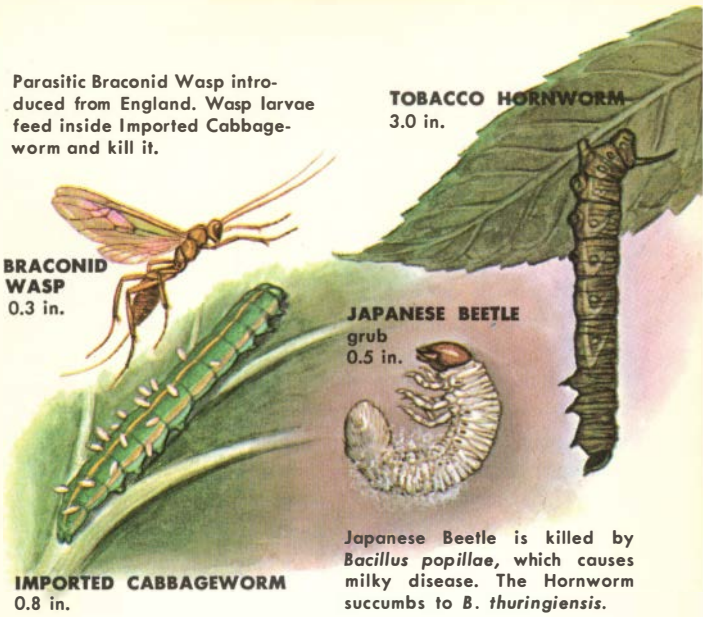
These tiny rove beetles feed on maggots. The larvae also burrow into pupae.



BIOLOGICAL CONTROL is the purposeful use of natural predators, parasites, or diseases to kill or reduce the population of a pest species. This method has been effective principally in combating insect pests introduced from foreign countries without their natural enemies. Biological controls are not usually practical for home gardens or similar small areas. They are used most successfully in orchards and groves or where large-scale crop plantings are repeated year after year on the same land. Usually the control species is at first bred artificially so that it can be introduced in large numbers. More than two dozen cases of effective large-scale control of insect pests have been achieved by this method.

Damage to citrus by the Cottony-cushion Scale in California was virtually eliminated by the introduction of Vedalia, an Australian lady beetle. Later, grove





owners began to spray their trees to kill aphids. At the same time they killed the Vedalia beetles, causing an outbreak of Cottony-cushion Scale again. The use of bacteria causing milky disease that kills grubs of the Japanese Beetle is another example of successful biological control. Gambusias and other top-feeding minnows are effective in the control of mosquito larvae. Interestingly, the Chrysolina Beetle was introduced to western United States from Australia to halt the spread of the Klamath weed.

Biological controls do not eliminate a pest species completely. They only reduce the population and thus keep the damage low. But biological controls are usually self-generating, so a control species, once established, continues to reproduce and to remain effective.

PHYSICAL AND MECHANICAL CONTROLS are the simplest, most obvious, and at times most effective: witness the old-fashioned fly swatter. Pests of stored products are commonly destroyed by heat or cold. Few can survive long in a temperature of 120 degrees F. or higher. Cold either kills or stops activity. Draining off standing water to eliminate breeding places is a standard mosquito control method, while many plant pests are killed by flooding. Lights are used to attract some kinds of pests, which may then be electrocuted on charged screens. Pests that collect in large numbers may be lured to baits or caught in ditches. The gardener who picks Japanese Beetles off his roses by hand uses an effective method for small areas.

CULTURAL CONTROL is an inexpensive method of checking or preventing damage by insect pests by combining mechanical or physical controls with a knowledge of the pest's life history. Crop rotation prevents the build-up of a pest population that feeds on one kind of plant. Burying stalks, weeds, and other residues after harvest destroys eggs, pupae, or hibernating larvae and adults. Similarly, early or late plowing may destroy a particular life stage of a pest. Planting and harvesting can sometimes be timed to escape periods of egg laying or of pest abundance. Varieties of plants resistant to particular pests can be planted. Healthy, vigorously growing plants can withstand insect attacks better than those that are weak or diseased. Likewise, animals in good health are not as greatly disturbed by pests.



Golden Regent, a resistant variety of sweet corn.

Spancross, a variety susceptible to Corn Earworm.

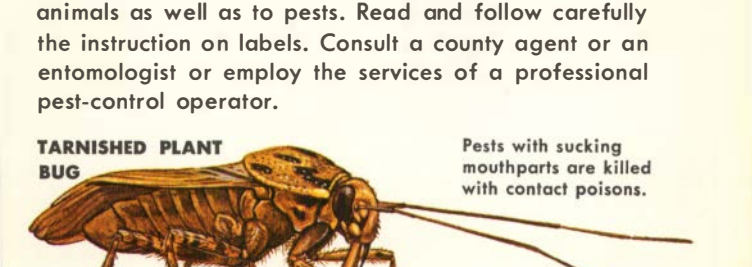


Stomach poisons are used mainly to kill pests with chewing mouthparts.

INSECTICIDES are poisons used to kill insect pests. Their great advantage is speed. Biological control methods, while safer and longer lasting, may require several seasons to become effective.

More than 350 million pounds of insecticides are sold annually in the United States. Their use increases agricultural yields by an average of about 25 percent and in many cases prevents complete crop losses. Insecticides are highly important, too, in the control of pests that are annoying or are disease carriers.

Most insecticides are dangerous to people and other animals as well as to pests. Read and follow carefully the instruction on labels. Consult a county agent or an entomologist or employ the services of a professional pest-control operator.



Pests with sucking mouthparts are killed with contact poisons.

APPLICATIONS of insecticides are rarely made full strength. *Dusts* are dry mixtures of from 0.1 percent to 25 percent of the poison mixed with fine particles of an inactive material, such as talc. *Wettable powders* are dusts that form a suspension in water for spraying; the powder may consist of from 10 to 95 percent insecticide. *Emulsifiable concentrates,* the most common formulation for applying insecticides, consist of oil or a similar organic solvent containing the insecticide and an emulsifier that aids the mixing of the droplets of oil and insecticide in water. The components may separate on standing but can be remixed by shaking. *Special solvents,* such as kerosene, pine oil, and other liquids of organic compounds, are used with the water-insoluble organic insecticides. Most solvents are toxic to plants, are inflammable, and may damage wallpaper, tile, and other materials. For all applications, follow printed directions with care.



SPRAYERS use a pump to build up air pressure that forces the liquid insecticide from the nozzle. The size of the nozzle opening creates either a foglike mist or a steady stream.

DUSTERS are powered by hand or by motor and use either a fan or compressed air to force out the dust in a cloud.

AEROSOL BOMBS, the most common household applicators, consist of an insecticide dissolved in a liquefied gas under high pressure. A fine mist is produced when these are allowed to escape from a small opening. Aerosols are convenient but are relatively expensive.

Bean beetles and their larvae (p. 76) feed on the underside of leaves. They can be reached with insecticide dusts.



STOMACH POISONS are used principally to kill insects with chewing mouthparts. They may be sprayed or dusted directly on the insect's food or may be mixed with baits to attract the pests. To be useful a stomach poison must kill fairly quickly, as the pest is already doing damage when it takes in the insecticide. Too heavy an application of these chemicals may kill the plants. The residues are poisonous to man and domestic animals. Contact insecticides (p. 18) act as stomach poisons if eaten. Arsenic compounds are the most common inorganic stomach poisons. *Paris green* (calcium acetoarsenite) was the first chemical insecticide used successfully on a large scale. *Lead arsenate, white arsenic* (arsenious oxide), *sodium arsenate,* and *calcium arsenate* are other arsenic stomach poisons. Fluorine compounds that act as stomach poisons are *sodium fluosilicate, sodium fluoride,* and *sodium fluoaluminate* (cryolite). *Thallium sulfate,* highly poisonous, is mixed with food to make ant baits. Do not store any insecticide where children can reach it. Make certain the containers are properly labeled and marked POISON.

CONTACT INSECTICIDES are sprayed or dusted directly on pests or are spread where pests will pick them up. They are especially useful in controlling insects with piercing-sucking mouthparts. All contact poisons act as stomach poisons (p. 17) if eaten. Most of them are also poisonous to people and animals and thus are a serious hazard if not used as directed. In excess amounts many contact insecticides are poisonous to plants. Some are used as fumigants. Always read the label before even opening the insecticide container. When in doubt about how to use an insecticide safely and most effectively, ask the advice of your dealer or of a county or agricultural agent.

Most of the many thousands of tradenamed insecticide formulations belong in the contact-insecticide group. These are divided into the following groups—*inorganics, natural organics* or *plant poisons, synthetics,* and *oils*. Each of these groups is described separately on the following pages. Most of the contact insecticides now used have appeared since the World War II development of DDT, the first widely used synthetic organic insecticide.

INORGANIC CONTACT INSECTICIDES, consisting mainly of *sulfur dusts,* mixtures of *lime* and *sulfur,* or *sulfur compounds,* were the first contact poisons used on a large scale and still rank among the most important. *Sulfur dust* is one of the main chemical controls for mites, for the crawling stages of scales, and for some kinds of caterpillars. Finely ground sulfur is usable as a wettable powder for spray applications. *Lime-sulfur solution* is a liquid, soluble in water. Lime-sulfur is also dehydrated and sold in concentrated powder form. It is used to control plant pests such as scales and also as a dip for cattle, sheep, and other livestock. *Bordeaux mixture* is a combination of copper sulfate and lime in water. In addition to their use as insecticides, sulfur and sulfur compounds are valued as fungicides. In hot weather, heavy applications of sulfur will burn foliage and fruit and so must be applied sparingly.

NATURAL ORGANICS were the earliest compounds used in killing insect pests. With the exception of nicotine, highly toxic to man and other mammals, they are the least dangerous of the insecticides to use on food plants or in the house.

Nicotine is obtained from the waste leaves of tobacco plants and waste tobacco products. It is used principally as *nicotine sulfate*, with a 40-percent nicotine content. The 40-percent concentrate is ordinarily diluted in 800 to 1,000 parts of water (about one teaspoon to a gallon) and is applied as a spray to kill aphids or other soft-bodied insects. Nicotine sulfate is used also as a stock dip for control of mites, ticks, and lice. Finely ground tobacco stems and leaves are used as a dust or burned as a fumigant. Nicotine may be added to aerosol formulations.

Tobacco plant, source of highly toxic nicotine



Pyrethrum comes from the flowers of several species of chrysanthemums. It is produced commercially from a species grown in East Africa. Fast-acting pyrethrins are the "knockdown" agents in most household sprays, with slower-acting DDT or other synthetics actually killing the insect. *Allethrin*, produced synthetically, is much the same as pyrethrum in action.

Rotenone is obtained from the dried and ground roots of the South American cubé and from the roots of two species of derris that grow in the East Indies. As prepared for an insecticide, rotenone is relatively nontoxic to humans, but as an insecticide it acts both as a stomach and as a contact poison. Another use of rotenone by biologists is as a poison to eliminate trash fish in lakes and ponds.

Other botanicals, or natural-organic contact insecticides, include *ryania*, produced from the pulverized stems and roots of a South American plant. Ryania is less toxic to mammals than rotenone and so is recommended for food plants where residues might be a problem. *Sabadilla*, which also has low toxicity, is made by grinding the seeds of a lily-family plant of Venezuela.

SYNTHETIC ORGANIC CONTACT INSECTICIDES are the most important group of chemicals used today in the control of insect pests. There are two groups: chlorinated hydrocarbons and organo-phosphates.

CHLORINATED HYDROCARBONS

DDT is the leader in the chlorinated hydrocarbon group. Though first synthesized in 1874, DDT was not recognized as an insecticide until World War II, when its initial large-scale use halted a typhus epidemic spread by lice in Italy. It was later valuable during the war years in the control of flies and mosquitoes and came into widespread use in the control of agricultural and household pests after the war. DDT is highly effective in killing many kinds of insects but is relatively nontoxic to aphids, spider mites, and some other species. Some cockroaches, flies, and other insects have developed resistance to DDT. When an insect comes in contact with DDT, it first appears to lose control of its voluntary actions; later it becomes paralyzed. Death comes slowly, sometimes several days later. DDT has a rather low toxicity to man and other vertebrates but may be stored in the fatty tissues of the body and cause death months later when the fat reserves are utilized.

DDT is applied as a dust, wettable powder, water emulsion, or in an oil base. Vertebrates absorb the oil-base DDT most rapidly. DDT is insoluble in water. Its residues may remain effective outdoors for many months or even years, indoors for even longer. *Methoxychlor*, related to DDT, is effective against the Mexican Bean Beetle and works more rapidly in killing the House Fly. *TDE* (or DDD), also a relative of DDT, is commonly used in mosquito control because it is less toxic than DDT to vertebrates. TDE is also less poisonous to insects, however.

Benzene hexachloride (BHC), also in the chlorinated-hydrocarbon group, was discovered as a useful insecticide about the same time as DDT. BHC kills faster than DDT and is commonly used in the control of crop pests. It has a distinctive musty odor and sometimes taints food. BHC is usually used as a dust or a wettable powder. *Lindane* is BHC that differs only in the arrangement of its atoms, but as it lacks the objectionable heavy odor, it is used more commonly in houses. Though its residual life is shorter than DDT's, lindane is about twice as toxic to many insects and apparently is not stored in the body tissues. *Toxaphene*, insoluble in water but soluble in many organic solvents, is an excellent insect killer but is also poisonous to vertebrates. Toxaphene is one of the most common insecticides for controlling pests of cotton.

Chlordane, dieldrin, aldrin, endrin, and *heptachlor* form another group of closely related chlorinated hydrocarbons. All are insoluble in water but are soluble in many organic solvents.



Scales may be killed with organo-phosphate sprays (below and p. 86). Use these insecticides with great care.

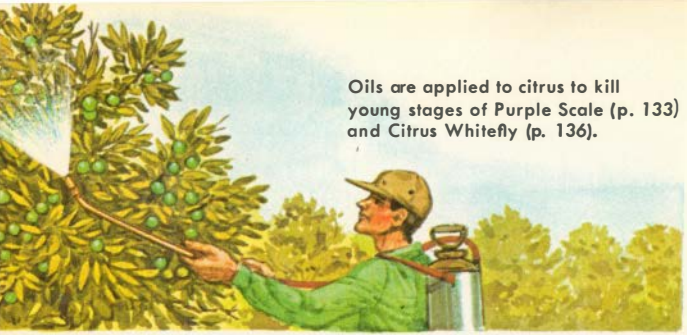
They are also used in dust or pellet form, particularly as soil poisons for the control of termites and ants. They are highly effective insect killers and are residual. They are also poisonous to vertebrates, including man and other mammals.

ORGANO-PHOSPHATES

The organo-phosphate group of contact insecticides stems from chemical research just before World War II, when some of these compounds were developed as poisonous gases for use in warfare. Most of them are extremely lethal to man and animals as well as to insects. They can be taken into the body through the mouth or the skin or by inhaling their fumes. Residues on foods are a source of danger. Because these insecticides are very poisonous, they must be handled with the greatest care.

Parathion, a brownish-yellow liquid with a garlic odor, is too poisonous for household use or for applying near livestock and pets, but it is widely used on fruit and vegetable crops. Residues disappear rapidly. *Demeton,* about as poisonous as parathion, acts as a systemic poison, being absorbed by the tissues of the plant. It kills pests that feed on the plant's juices without affecting predators and pollinators. *TEPP,* even more poisonous than parathion, decomposes rapidly and leaves no residue. It is used regularly on food crops.

Malathion, most commonly used organo-phosphate, is not highly toxic to vertebrates. Malathion will kill many insect species that have developed a resistance to the insecticides of the DDT and chlordane groups. *Diazinon, DDVP, ronnel,* and *dicapthon* are other organo-phosphates that are excellent insect killers. DDVP is the most highly toxic of these chemicals to man and animals.



Oils are applied to citrus to kill young stages of Purple Scale (p. 133) and Citrus Whitefly (p. 136).

OILS, principally petroleum but also some animal and vegetable oils, serve as carriers for insecticides or may be used as insecticides themselves. *Dormant oils,* rather heavy and semirefined, are applied in late winter or early spring to trees or shrubs that are not in foliage to kill scales, mites, eggs, and some larvae. *Summer oils* are lighter and more highly refined, hence less damaging to plants; they are used to control aphids, scale insects, and mealybugs. As the oils themselves are toxic to plants if applied full strength, they are mixed with water by adding an emulsifier, such as soap. This distributes the oil evenly as small droplets. Oil baths may be used to kill such parasites as fleas, lice, ticks, and mites on domestic animals and pets. Formulations that require shaking with a small amount of water before final mixing are called *miscible* oils. An *emulsible*-oil formulation can be poured directly into the water.

FUMIGANTS are gases used to kill insects in enclosures, as in buildings or containers, in the soil, or under such temporary covers as tarpaulins and tents. Many fumigants are inflammable. Nearly all fumigants are more poisonous to man than to the insects and should be used only by a professional pest-control operator. Their advantage is their penetration to all parts of buildings, into stored products or plants. They leave no residue. *Carbon disulfide* (carbon bisulfide), highly inflammable, is used mainly as a soil fumigant for ants, termites, and grubs. For indoor use it may be mixed with carbon tetrachloride to reduce the danger of fire or explosion. *Dichloropropene* and *dichloropropane* are also used as soil fumigants. *Hydrogen cyanide,* which has a distinctive nutty odor and is deadly poisonous, is used to fumigate mills and warehouses or fruit trees under tents. *Methyl bromide,* a noninflammable fumigant, is valued because of its power to penetrate tightly packed materials. *Paradichlorobenzene* ("para" crystals) and *naphthalene* (both sold as mothballs) vaporize slowly and act as a fumigant and a repellent.

REPELLENTS are chemicals that by their odor or taste prevent insect attacks. They are used mainly to protect man, animals, or stored products; less commonly, plants. Some repellents are poisonous if touched, eaten, or breathed. *Mothballs* are repellents that protect clothes from insect damage. Creosote is used as a barrier against crawling insects, while *smoke screens* ward off flies and mosquitoes. Among the most successful of dozens of repellent chemicals are *diethyl toluamide, dimethyl phthalate,* and *ethyl hexanediol.* These organic chemicals are diluted with oils and disguised with perfumes. They are sold under many tradenames. Most will repel insects for one to five hours.

NEW METHODS of combating insect pests are being developed every year. Some are useful only in large-scale control programs, others in home and garden. Among the most promising are *sterilants* that render insects incapable of reproducing. This method was first used with success to control the Screw-worm. Millions of males, sterilized by radiation, were released in areas of infestation to mate with females, which then produced infertile eggs. *Hormones* are used to cause an insect to pass from one stage of its development to the next irrespective of season. Thus, pupae can be made to transform into adults in midwinter or larvae may be made to pupate before they are full grown. Insect hormones are apparently harmless to other living things. Also safe are such *nontoxic insecticides* as finely ground silica, which abrades the outer covering from an insect and causes it to dry up, or desiccate, as its body fluids escape.

The soil in seed beds can be fumigated by releasing methyl-bromide gas under plastic cover.







ODOROUS HOUSE ANTS, widespread in U.S., give off a sweet odor when crushed. Travel definite trails to find food.

ARGENTINE ANTS are common in southern U.S.; worst ant pests in houses. Prefer sweets but eat all foods. Bite, do not sting.

HOUSEHOLD PESTS

Insect pests may destroy the timbers of a house, tunnel into furniture and fabrics, or raid the contents of the kitchen, from the spice cabinet to the garbage pail. Some kinds bite, sting, or transmit diseases. Others are simply annoying, uninvited guests.

The basic step in controlling household pests is to keep them out. Screen windows and doors, seal cracks, and remove debris in which pests can hide or multiply. If pest infestations are heavy, persistent, or unexplainable, services of a professional pest-control operator may be necessary. Make certain the man employed represents a licensed, bonded organization.

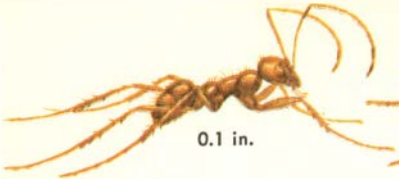
Many pests can be recognized and controlled without expert help. Since insecticides are poisonous and will be used where there are people, pets, and food, follow carefully the directions given on the label.

THIEF ANTS often live in other ant nests and feed on larvae. They prefer cheese, meats, or other greasy food.

PHARAOH ANTS also like meat. May nest in walls and then invade all parts of house. Poison baits are best control method.







CRAZY ANTS, native to India but now widespread, run "crazily" on their long legs. They eat meat, greasy foods, and sweets.



CORNFIELD ANTS are the common "red ants" of northern states. Nest mounds often numerous on lawns. Invade houses.

ANTS live in colonies in the ground, in the foundations or walls of buildings, beneath bark or stones. A colony contains numerous workers (sterile females), one to several queens, and a few males during part of the year. Workers do not have wings, but males and females are winged at swarming time. Males die after mating, and the queens drop their wings and find a place to start a colony. After mating, queens remain fertile, living as long as 25 years. Queens are usually several times larger than workers, which attend their every need. Ants belong to same insect order as bees and wasps. They have elbowed antennae and a thin waist, distinguishing them from termites (p. 26).

The most effective control is to destroy the nest if it can be found. Chemical barriers, using a residual contact insecticide, can be placed around foundations of buildings. Workers will carry poisoned baits to the colony and thus kill even the queen.

SOUTHERN FIRE ANTS occur in warm parts of U.S. Often nest near buildings. Invade houses. Stings are painful.

BLACK CARPENTER ANTS excavate galleries and nest in wood. They enter houses to get sweets. Bite but do not sting.





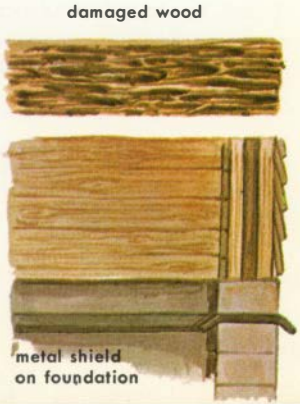
TERMITES are primitive social insects, more closely related to cockroaches (p. 28) than to ants (p. 25). A colony consists of numerous whitish, wingless, blind *workers;* a lesser number of *soldiers,* with large brownish heads equipped with powerful jaws or with a bellows-shaped snout that expels a sticky or odorous fluid; and *reproductives,* the king and queen. Additional winged males and females are produced for swarming, which takes place in spring or after rains in warm weather. After a short flight they break off their wings and mate. Each mated pair then crawls off in search of a suitable place to establish a new colony.

More than 50 species of termites occur in the U.S. Their spread as far north as Minnesota in recent years is attributed to increased use of central heating in buildings, enabling them to survive winters. Nearly all U.S. species live in the soil; many of the more than 2,000 species of the tropics build aboveground nests.

Termites eat wood but cannot absorb it until the cellulose is converted into soluble substances by protozoans that live in the termite's digestive tract. Neither animal is able to survive alone.



termite tubes up foundation



SUBTERRANEAN TERMITES live in colonies in soil, and workers travel through tunnels or mud tubes to the wood above. Fungi that grow in moist, dark tunnels are eaten by termites, supplying protein and vitamins.

Swarming flights or mud tubes up a foundation are evidence of a termite infestation. In late stages, floors sag as eaten-out beams crumble.

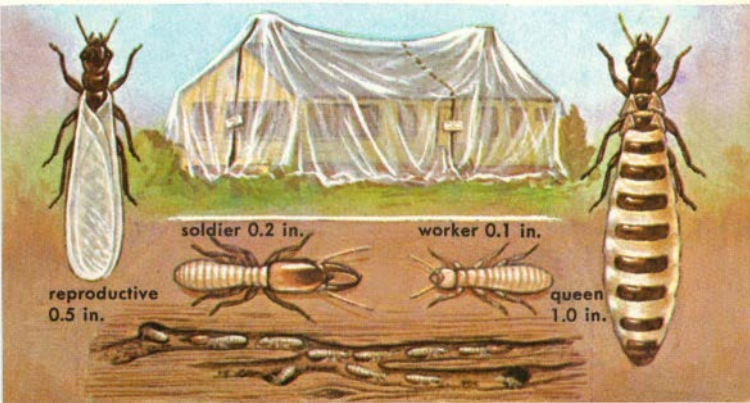
To control, no wood of a building should touch soil. Preventive measures should be taken as a building is being constructed. Place metal shields between the foundation and sills and allow air to circulate under buildings. Because of the special equipment needed, use a professional pest-control operator, especially in treating a building already erected. He will force penetrating insecticide into the wood or foundation, treat the soil beneath buildings, or use a fumigant. Inspect regularly to detect renewed activity.

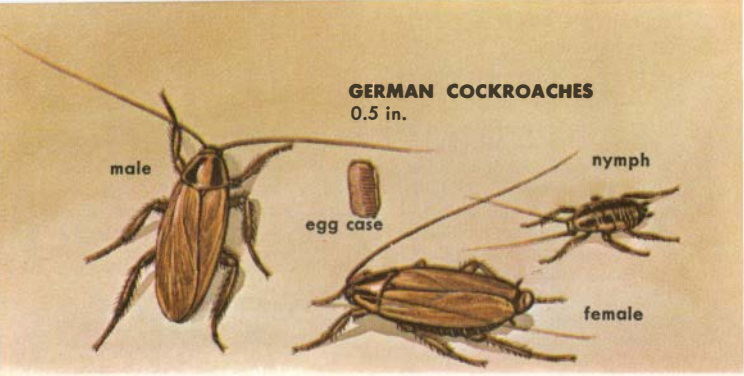


worker 0.2 in. reproductive 0.5 in.

DRYWOOD TERMITES are prevalent in the southwestern U.S. No contact with soil is necessary. Often they invade a house at roof level and may infest furniture or books. Piles of brownish, seedlike excrement pellets pushed from tunnels are signs of their presence. Preventing entry is not economical. Control, which should be done only by experts, consists of forcing insecticide into tunnels. Poison is spread as workers groom each other. House or infested object may be fumigated, but this does not prevent reinfestation.

EASTERN SUBTERRANEAN TERMITE



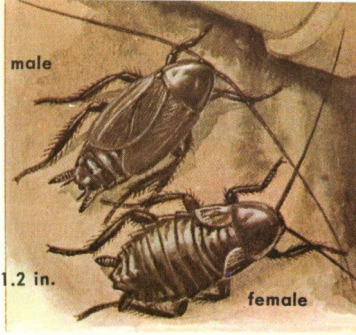


COCKROACHES feed on a great variety of foods—meats, cheeses, sweets, and starches, including the starch in clothing or in the glue of book bindings and stamps: When very abundant, they may also eat human hair, skin, and nails. Cockroaches secrete a sticky, odorous fluid that may be left on foods or materials. Fortunately, cockroaches appear to be only incidental carriers of diseases.

Most of the more than 3,000 species of cockroaches live in the tropics or subtropics. About 55 occur in the U.S.; only four species are common household pests.

Normally cockroaches are active only at night. They develop by a gradual metamorphosis—egg, nymph, and adult. Egg cases contain two rows of eggs, and the nymphs escape through a seam along the side. Nymphs look like adults but lack wings and may be a lighter color. After a period of growth and several molts they become adults. The time required for them to mature varies with the species and also with the season and the region. Temperature and moisture as well as food are important factors in their development.

The best permanent control for cockroaches is eliminating accessibility of foods which they eat.



GERMAN COCKROACHES, or Croton Bugs, are common in U.S., especially in northern states. Dark stripes on shield behind head are distinguishing. Both sexes winged and active.

German Cockroaches commonly enter houses in bags or boxes from grocery stores. They tend to cluster in warm, moist places, as around hot-water pipes, and stay hidden when not feeding.

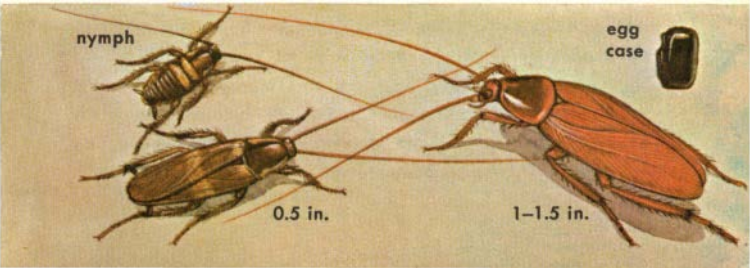
Females carry the egg capsule, containing 24 to 48 eggs, until hatching time. Nymphs may emerge while the capsule is still attached to the female.

In most areas German Cockroaches are resistant to DDT, chlordane, and other chlorinated hydrocarbons. They can be controlled with organo-phosphates, such as malathion.

ORIENTAL COCKROACHES, also called Black Beetles or Water Bugs, are most sluggish of domestic cockroaches. Females have short useless wings and are slightly larger than males. Commonly infest damp basements. Contact-insecticide barrier around a foundation blocks entry of these cockroaches and other crawling pests.

BROWN-BANDED COCKROACH has two light bands across the base of its wings. Unlike other cockroaches, it is as common in the bedroom as in the kitchen, requiring warmth but not as much moisture. Control is difficult because these cockroaches are found so widely through the house. The most effective way to reach them is with fumigants, keeping room or house closed for several hours.

AMERICAN COCKROACHES are the largest cockroaches in the U.S. Both sexes are winged, their flight gliding and fluttery. The female deposits her egg capsule soon after it forms, sometimes gluing it to a surface. In the South these cockroaches are common outdoors, where they live under bark or in vegetation. They can be controlled with contact insecticides or lured to poison baits.



CLOTHES MOTH larvae feed on woolen fabrics, feathers, fur, mohair, and other animal products such as dried milk and meals. The adult moths, commonly called "millers," do not eat, and unlike most other moths, are not attracted to lights.

Material likely to be attacked should be cleaned and exposed frequently to light. Brushing clothes dislodges the eggs and larvae. Storage of furs at a temperature of 45 degrees or cooler prevents development of moths or will kill them if the temperature is raised and lowered several times during the storage period. Items can be sprayed with residual contact insecticides or washables rinsed in an insecticide solution. These treatments kill the insects as they feed. Mild fumigants such as paradichlorobenzene crystals or naphthalene flakes discourage moth attacks. These insecticides will also kill moths already in the fabrics but are effective only when used in tight containers or closets. An infestation may persist and spread from larvae that feed and develop on lint in cracks in the floor, beneath baseboards, or in vents. In heavy infestations an entire house may be fumigated. This should be done only by a professional exterminator.

DERMESTID BEETLES are pests of fabrics and upholstered furniture and also infest cured meats, meals, cheeses, hides, hair, flour or other grain products, and spices. They are serious pests in museums. Outdoors they are valuable as scavengers. Larvae of dermestid beetles are more active than the larvae of clothes moths. Adults fly in daytime. They commonly feed on the pollen of flowers and also breed outdoors. Treatments effective for clothes moths also control carpet beetles. In both cases, good housekeeping to eliminate breeding places is the most important preventive.

WEBBING CLOTHES MOTHS are common fabric pests that occur throughout the world. Females lay eggs about 0.02 of an inch long (barely visible), either singly or in small groups, sticking them to the threads of fabrics. Eggs hatch in a few days to several weeks, depending on temperature and humidity. The larvae are so tiny they can crawl between the woven threads of fabrics. They spin a silky webbing or tunnel as they feed, sometimes moving to another spot if their food runs short. Damage is most common under collars, in cuffs, or in other dark areas of garments. Full-grown larvae spin a silken cocoon from which they emerge as adults in three to six weeks.





eggs, larvae and cocoons on fabric.

CASEMAKING CLOTHES MOTH larvae spin a case of silk and fabric, carrying it with them as they feed. The case splits and the "V" of the split is filled in as the larva grows. Common in northern states. Plaster Bagworms of southern states build a portable case of bits of plaster or fabric woven into the silk of the case.

CASEMAKING CLOTHES MOTH

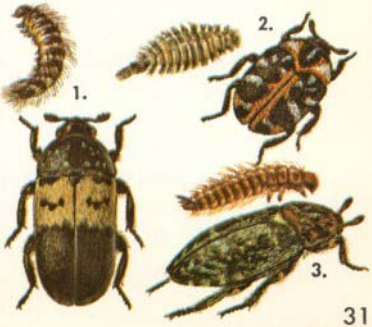


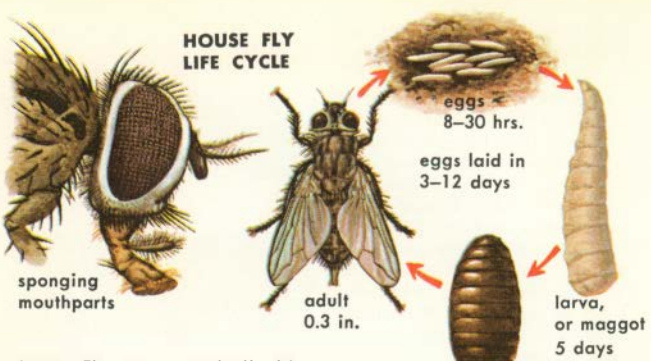


PLASTER BAGWORM

CARPET BEETLES, also called Buffalo Beetles, are dermestids that infest woolen fabrics, feathers, and other animal products. Related pests include the larger Hide Beetle and the Larder Beetle. Hides and skins are treated with arsenic powders or similar stomach poisons. Cheese, cured meats, and other fatty foods should be kept in tight containers or under refrigeration.

1. **LARDER BEETLE,** 0.3 in.; 2. **CARPET BEETLE,** 0.2 in.; 3. **HIDE BEETLE,** 0.3 in.





House Fly can eat only liquids. It salivates on solids to dissolve them, then sponges up liquid.

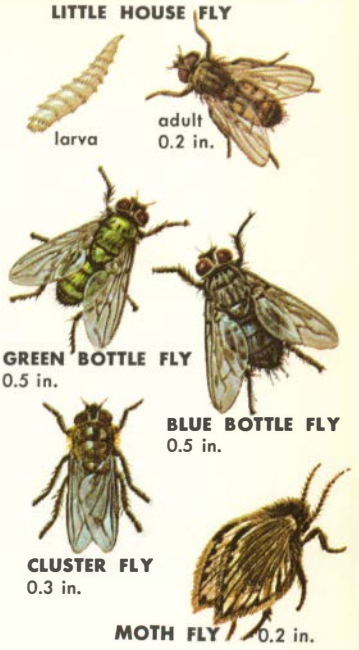
HOUSE FLIES are bothersome, dangerous pests, transmitting diseases and parasites from the filth in which they breed to the foods man eats. Females may lay half a dozen or more clusters of 100 to 150 eggs in a season. In favorable conditions a life cycle is completed in about two weeks but may take many months in cold weather. Winter is ordinarily passed in the larva or pupa stage, but adults may overwinter in warm niches. Disposal of garbage, manure, sewage, and similar decaying or fermenting wastes in which the flies breed and the maggots develop is most important. Windows and doors should be fitted with tight screens. Flies that enter can be killed with aerosol sprays. Walls, sills, and screens can be treated with residual surface sprays. As flies in most areas are resistant to DDT, other contact insecticides must be substituted. Poison baits (mixtures of syrup- or sugar-water with an insecticide) are effective in places that cannot be screened or where sprays cannot be used because of danger of contamination.

LITTLE HOUSE FLIES are smaller and more slender than the House Fly. They hover or fly back and forth without settling on food. The similar, closely related Latrine Fly breeds in human excrement. Maggots of both have a flattened, spiny body.

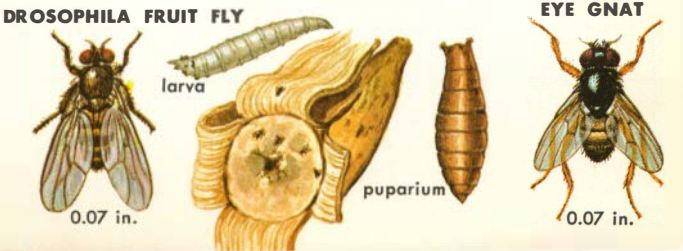
BLOW FLIES are large and noisy. Most species are metallic blue or green, like the Green Bottle and Blue Bottle flies shown here. The gray Cluster Fly, similar in appearance to House Fly, is a blow fly common in houses. Blow fly maggots develop in garbage or carrion.

MOTH FLIES, their wings and body covered with hair, often appear in sink or bathtub drains. The maggots develop in the gelatinous sludge in the bends of pipes. Sometimes large numbers invade from outdoors, where they develop in garbage or sewage. They are so tiny they can crawl through screens.

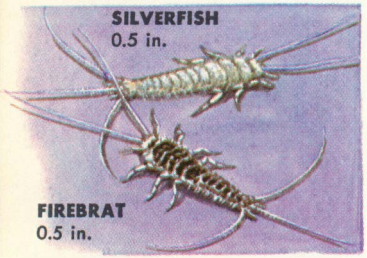
FRUIT FLIES can enter houses through ordinary screens. They are attracted to rotting or fermenting fruits or liquids. A complete life cycle requires less than two weeks. Other common names for them are Vinegar Flies or Pomace Flies.



GNAT is a name used for many kinds of small flies, most of which are only nuisances. The Eye Gnat, attracted to eye secretions, transmits pinkeye. These persistent tormentors are most active in early morning or evening hours.



MANY OTHER KINDS of insects, as well as spiders, and their kin enter houses, where they are either nuisances or potentially dangerous pests. Some of these are discussed in the section on insects that bite or sting (p. 38), others in the section on stored products (p. 146). Often an invasion of insects is only temporary, as when they are attracted to lights. When a lawn is mowed, a vacant lot is cleaned up, or a crop is harvested nearby, insects disturbed from their normal living places may be temporary pests. Others are regular visitors and companions in dwellings.



SILVERFISH are scaly, wingless insects that prefer foods with a high starch or sugar content. They eat the glue in book bindings or from wallpaper and often damage paintings or paper. Silverfish prefer cool, damp places; the closely related Firebrat lives in warm, drier spots. Residual sprays or dusts are effective in keeping down infestations.



EARWIGS are easily recognized by forceps at end of abdomen. Sometimes occur in large numbers in houses. They can bite and also pinch, but seldom break the skin. They hide during the day, feed at night. Use residual sprays or dusts.



HOUSE CRICKETS sing on the hearth or wherever they can find warmth. When cold, they are sluggish and quiet. Field Crickets also enter houses in autumn. As house pests, crickets eat a variety of foods and may be destructive to clothes. Household sprays, dusts, and poison baits are usually effective.

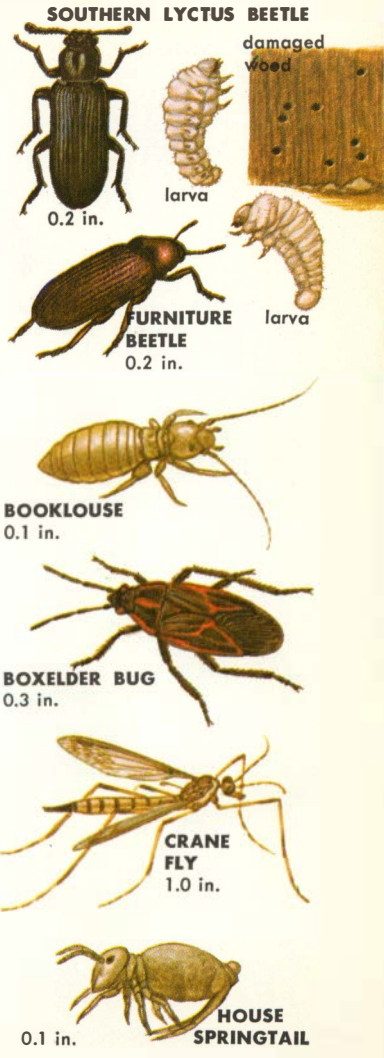
WOOD-BORING BEETLES of a number of species may infest wood used in houses or furniture. Larvae of the Southern Lyctus Beetle reduce wood to a fine powder, which is pushed outside through small holes. Droppings of the Furniture Beetle and others are round pellets. As some kinds feed, a ticking noise in the wood can be heard. Fumigation by a qualified pest-control operator is the best control.

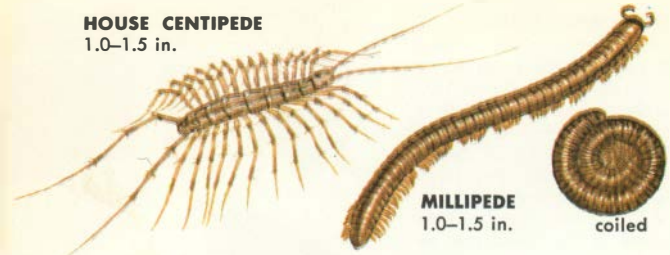
BOOKLICE, or Psocids, sometimes become abundant in stored furniture, books, or papers, particularly if damp. They feed mainly on molds but also eat cereals. Booklice are so small that it is difficult to keep them out of a house. Use contact sprays or dusts.

BOXELDER BUGS do not bite, sting, or carry diseases, but are annoyances when large numbers occur near or in houses. Can be killed with household sprays.

CRANE FLIES look like large mosquitoes but are harmless. Their larvae, or maggots, sometimes called leatherjackets, develop in damp vegetation or in the soil. Adults commonly are attracted to the lights in houses. They can be killed with household fly sprays.

SPRINGTAILS often congregate in cellars or in bathrooms or kitchens, wherever there is dampness. They are harmless and can be killed with household sprays or dusts.





CENTIPEDES are flat-bodied, with long antennae and one pair of legs on nearly every trunk segment. The House Centipede feeds on ants, flies, cockroaches, and other pests, hence is beneficial. Its bite, though rare, is painful. Use residual contact insecticides or treat joists, subfloors, and cracks with creosote or other repellents.

MILLIPEDES are almost cylindrical, with two pairs of short legs per apparent body segment, and short antennae. They move slowly. These features distinguish them from swift-crawling centipedes. Normally millipedes are found only outdoors, feeding on decaying vegetation, but they may invade houses after rains or to escape cold in fall.



PILLBUGS AND SOWBUGS are land-dwelling crustaceans. They can survive only in damp places, as in leaf mold or in basements. They feed mainly on decaying vegetation but also eat tender roots of plants. Controls: cleanup of debris in which they thrive; contact insecticides; poison baits in heavy infestations, as in greenhouses.

SCORPIONS are spider relatives found only in warm climates. Two species in southwestern U.S. are highly poisonous. Scorpions are nocturnal and feed mainly on insects, which they catch in their pincers, then paralyze or kill with their sting. Eliminate debris close to buildings and use contact insecticides that have residual action.



DADDYLONGLEGS
body 0.2 in.
2–3 in. across legs



HOUSE SPIDER
0.3 in.

DADDYLONGLEGS, or Harvestmen, resemble spiders but have a distinctly segmented abdomen and stink glands. They lack silk glands. Their long stiltlike legs are easily shed when the animal is touched. Daddylonglegs are harmless, feeding mainly on dead insects. They will kill and eat small insects, however, and may feed on fruits or vegetables.

JUMPING SPIDERS of several species often enter houses. They do not make webs. Instead they hunt actively for prey, searching over ceilings, walls, sills, and floors. They can jump quickly, and frequently use their silk as a payout line to let themselves down from high levels. These lines may be a nuisance, but the spiders are helpful.

BLACK WIDOW SPIDERS are widely distributed and rather abundant. Their bites are painful and may cause death. A doctor should be called immediately to give treatment. Fortunately, Black Widows are shy and do not bite without great provocation. They usually build their webs in or beneath objects close ta the ground.

HOUSE SPIDERS bother housewives because of their webs. Their bites may be very poisonous. House Spiders prey on the House Fly and other insects. Their webs are usually built in corners, where they collect dust as well as prey. These and other spiders can be killed with contact sprays or dusts; residual insecticides prevent reinfestation.



JUMPING SPIDER
0.4 in.



female
0.5 in.

BLACK WIDOW SPIDER

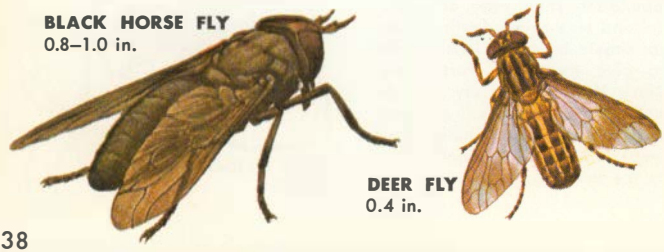
male
0.2 in.

INSECTS THAT BITE OR STING

Biting flies feed on the blood of their victims. They cut or stab through the skin with their knife-sharp piercing mouthparts, then lap up blood that flows from the wound. They may also be carriers of diseases.

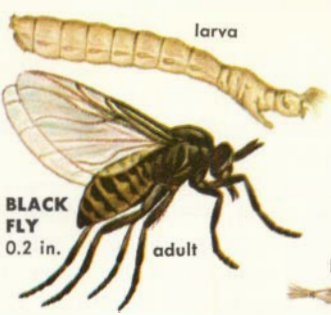
Insects that sting usually do so as a defense when disturbed or annoyed. Stings of bees or wasps may be extremely painful and also dangerous. In the United States more deaths result from insect stings than from the bites of poisonous snakes. Medical knowledge about the effect of insect venoms and how to treat stings is still limited. Usually there is swelling and in many cases a throbbing ache that may last for several days. Stings vary in severity with the species of insect and also with the amount of poison injected. A sting in an arm or a leg is less dangerous than a sting in the neck, where the poison may paralyze the vocal cords or hamper breathing. The effect of a sting also varies with individuals and with their physiological condition. Beekeepers commonly build up an immunity to stings.

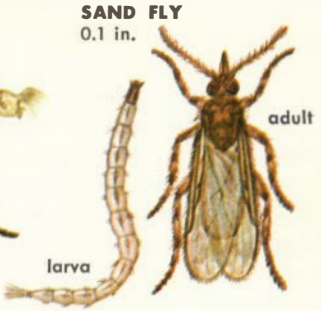
HORSE FLIES, active only in the daytime, are mainly pests of livestock (p. 56) but may also bite people. The bite, only from females, is very painful. Females lay egg masses on leaves, stems, or rocks.. On hatching, larvae drop to ground and complete development in damp soil or in water. Maggots may overwinter in mud, pupate in early spring, and emerge as adults a few weeks later. Equally pestering are closely related Deer Flies.



BLACK HORSE FLY
0.8–1.0 in.

DEER FLY
0.4 in.

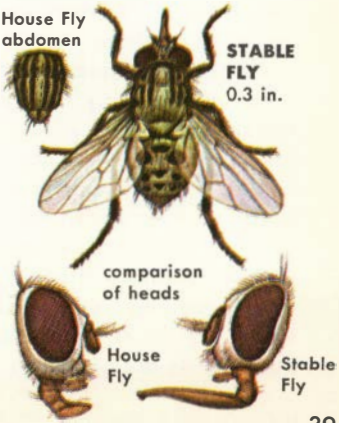




BLACK FLIES, also called Buffalo Gnats, are most abundant in late spring and summer in wooded regions of Canada and the U.S. These humpbacked bloodsuckers (only the females bite, causing a persistent irritation) crawl annoyingly into the eyes, ears, and nostrils. Females fasten their egg masses to rocks or vegetation in streams, in which the larvae develop and spin cocoons. A life cycle is completed in about six weeks. Repellents are effective.

STABLE FLIES, like Horse Flies, are principally pests of livestock but may at times bother people. They occur most abundantly in lowlands and seashore areas, becoming especially aggressive when the barometer is falling. Both sexes bite. Their mouthparts are sharp and stiletto-like rather than sponging, as in House Flies. In cool areas, they overwinter as larvae or pupae; in warmer climates, active the year around. In houses, can be killed with sprays. Eliminate breeding places (manure or decaying organic matter).

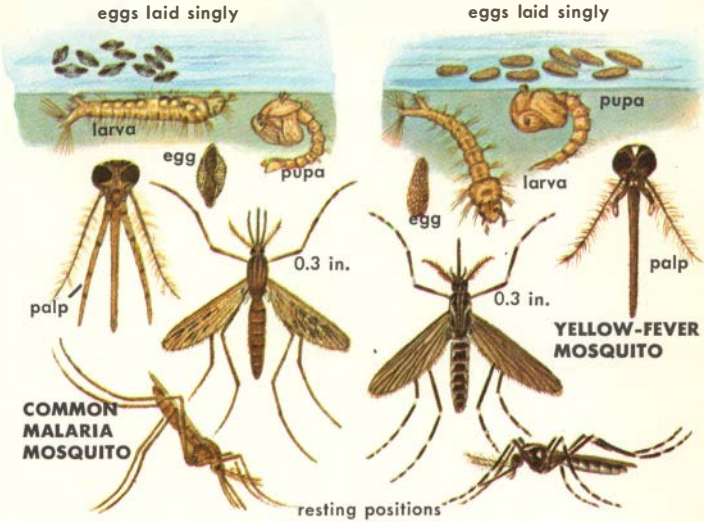
SAND FLIES, or No-See-Ums, are tiny bloodsucking flies, so small they can go through ordinary screens. They are most active in evening or early morning hours, and their bites are extremely painful. Screens and areas around lights can be sprayed or painted with an oil-emulsion contact insecticide. Repellents will keep the flies off in daytime. The maggots develop in moist vegetation or in pools (some species in salt water, others in fresh).



MOSQUITOES total more than 2,500 species. Many are carriers of diseases (malaria, yellow fever, dengue, and filariasis). Others, as annoyances, cause costly losses of man-hours to outdoor workers or reduce the pleasure of being outdoors.

Adult females lay their eggs on or near the surface of permanent pools or in moist or temporarily flooded locations. Some species lay their eggs singly; others deposit them in "rafts" of as many as several hundred. In most species the female must have a meal of blood before she can produce eggs. Males are nectar feeders and do not bite. The larvae, also called "wigglers," swim or rest just beneath the surface. They feed on microscopic organic matter. Development may be completed in as short a time as five days or may require several months; the average is a week to 10 days. Then the larvae transform into pupae, also known as "tumblers" because they continue to be active. The adults emerge in from two days to two weeks or longer, depending on the species and the water conditions. Adults live for a few days to several months, and most species do not travel more than a mile. Some hibernate in the adult stage.

Large-scale mosquito control consists of eliminating breeding areas by drainage, spreading oil films over the surface of the water, using insecticides to destroy the larvae or pupae, or spraying with contact insecticides to kill the adults. All of these controls may also destroy habitats or kill fish, birds, or other valuable wildlife and should be undertaken only after careful study by professionally trained people. Around houses, get rid of breeding places, such as ditches, low spots where water stands in lawns, or containers. Screening will keep adults out of houses.



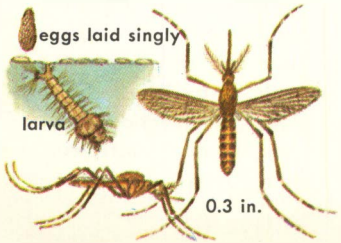
COMMON MALARIA MOSQUITO and the Western Malaria Mosquito, known to migrate 25 miles in spring flights, transmit malaria in N.A.

YELLOW-FEVER MOSQUITO, found mainly in port areas in South, is recognized by silvery stripes. Unlike most mosquitoes, it bites during day.

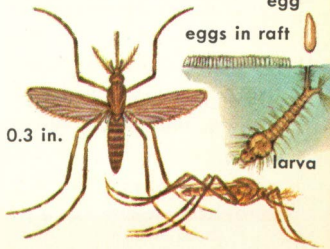
SALT-MARSH MOSQUITOES breed in large numbers along Atlantic and Gulf coasts. A related black species occurs in South, others in West.

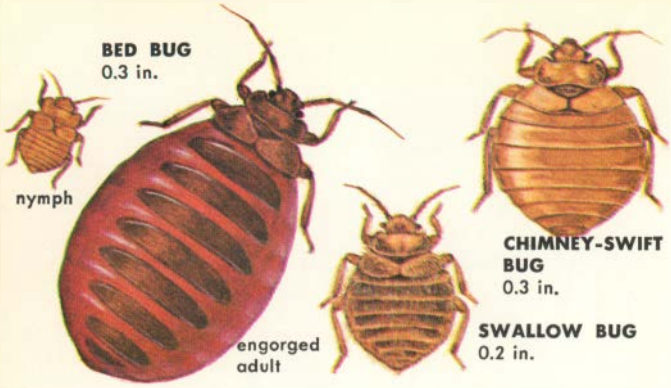
HOUSE MOSQUITO, worldwide in distribution, becomes active and bites at night. Members of this genus carry the virus causing encephalitis.

SALT-MARSH MOSQUITO



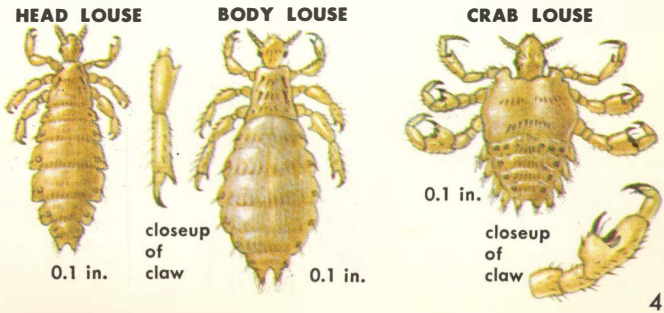
HOUSE MOSQUITO





BED BUGS feed on the blood of birds and mammals, including man. Both males and females bite, and as a rule, are active only at night. They pierce the skin and inject saliva that later causes the bite to itch or swell, the degree of irritation varying with the sensitivity of the individual. After becoming engorged, in five minutes or less, the bugs crawl away to hide. Bed Bugs breed the year around. Each female lays four to five eggs a day over a period of about two months, gluing them to rugs, furniture, or walls or laying them in cracks or crevices. The nymphs resemble the adults but are pale. After feeding and shedding (five molts), they become adults, living as long as a year. Bed Bugs are transported in bedding, furniture, or clothing. Heavy infestations can be detected by the odorous secretions given off by the bugs. Related species such as the Bat Bug, Chimney-swift Bug and Swallow Bug may also become pests in houses at times. To eliminate, spray floors, furniture, and walls with a residual contact insecticide in oil or water emulsion. Fumigation, necessary if infestations are spreading from chimneys or similar locations, should be done by a professional.

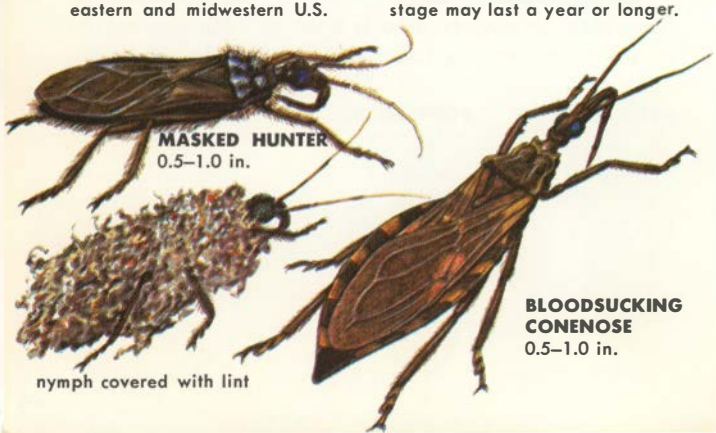
LICE are wingless insects parasitic on a variety of host animals. Those infesting pets, poultry, and livestock are described on pages 52–53. Three types may occur on humans. The Head Louse confines itself almost exclusively to the hair of the head, to which it glues its eggs or nits. The Body Louse, similar to the Head Louse in appearance, hides in clothing when not feeding. It lays its eggs in the clothes, especially in the seams. The Crab Louse, nearly as broad as it is long, lives among the coarse hairs of the body. The stout, curved claws on its first pair of legs do not form a locking device, as do those of the Head Louse and the Body Louse. All three types are bloodsuckers that may become abundant in unsanitary conditions. Their bite is not felt immediately but later becomes an itchy swelling. Lice are carriers of typhus fever and other diseases, transmitted through their bites. Young lice resemble the adults both in appearance and habits. Complete development, from egg to mature adult, takes about a month. Lice can be killed by dusting the clothing and body with a contact insecticide, such as DDT. Clothing can also be washed in an insecticide solution. Living quarters should be fumigated or subjected to a heat of 160 degrees F., steam or dry, for six hours or longer to destroy eggs.



ASSASSIN BUGS also go by the name of Conenoses because their head and mouthparts form a conelike beak. These insects bite quickly when disturbed. They should be brushed off swiftly but gently, and no attempt should be made to pick them up. They are bloodsuckers, thrusting their beaks forward to pierce the skin of their victim. The bite of some species is painless; the bite of others is extremely painful, the effects of the venom often lasting for months. Some are carriers of diseases, such as the very dangerous Chagas' disease of the American tropics. Some live in the nests of bats, rats, and other mammals. Where conenoses are abundant, spraying around doorways and lights with a residual contact insecticide will help to control them.

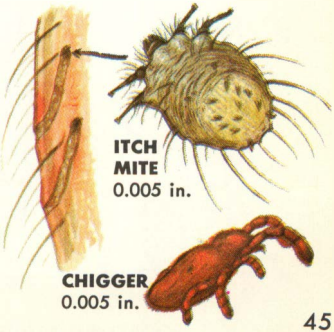
MASKED HUNTERS prey on Bed Bugs and other insects, from which they suck blood. The nymphs are covered with a sticky secretion to which lint and other camouflaging debris adheres to "mask" them. Also known as Kissing Bugs, the adults feed on warmblooded animals and may bite man. Occurs in eastern and midwestern U.S.

BLOODSUCKING CONENOSES, of southern and southwestern United States and Mexico, are known in some areas as Mexican Bed Bugs. At times they become locally abundant and may enter houses. They feed at night. Outdoors the eggs are laid on plants; indoors, in dark, dusty cracks or corners. The nymph stage may last a year or longer.

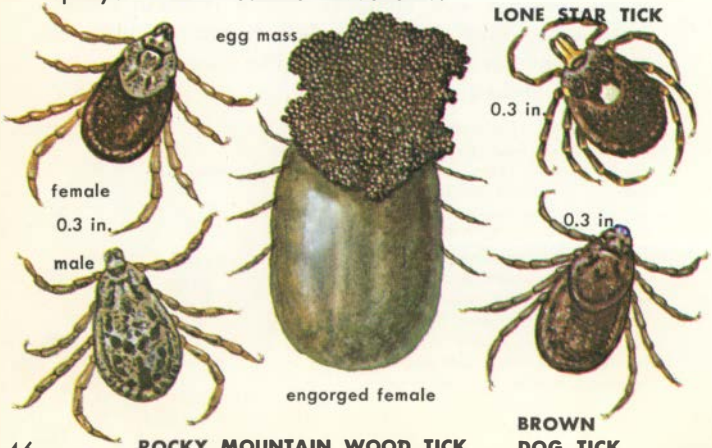


CHIGGERS, also called Jiggers or Red Bugs, are parasitic mites, more closely related to ticks and spiders than to insects. Some of the many species of mites are pests of poultry, pets, and livestock (p. 54). The tiny reddish adult chiggers, just visible to the naked eye, may be seen scurrying about in litter or in soil. The smaller larval stage that attacks man is the first of two stages before the mites become adults. The larvae wait on grass, leaves, or in litter for a victim. They usually crawl until they reach a belt line, an armpit, or similar obstruction, and there stop to feed by inserting their mouthparts into the skin to draw out fluids. When full, they drop off. As they feed, they release into the bite a digestive fluid containing a toxin that liquefies the cells and tissues and later causes swelling and intense itching. Dusting the clothing, particularly the cuffs, sleeves, and neckline areas, with sulfur helps to discourage chiggers, as do insect repellents. Or, before going into grassy or brushy areas, cover your arms and legs with a soapy lather and allow it to dry. Treat lawns infested with chiggers with a residual contact insecticide, and eliminate such breeding spots as weedy patches or plant debris. The chigger bites can only be soothed with ointments.

ITCH MITES spend their entire life on their host. Females burrow into the skin, sometimes making a tunnel an inch long, in which they lay as many as two dozen eggs. Both the tunneling and the feeding cause the itching, or scabies, and the bite spot commonly becomes infected. Ointments prescribed by a doctor will get rid of the mites and relieve the itching. Clothing and bedding should be sterilized.



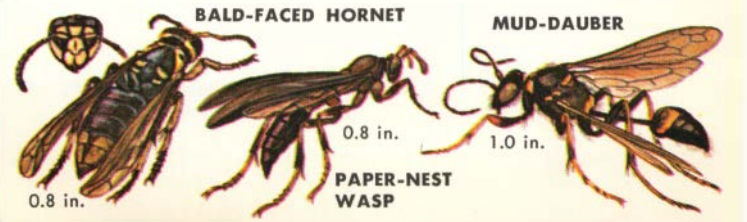
TICKS of several species are bloodsucking pests of man and his pets and livestock (p. 48). They are more closely related to spiders than to insects. Some ticks transmit diseases, the most dangerous of which is spotted fever. Bites of some ticks cause paralysis. When a tick is attached, do not try to pull it off, as the head and mouthparts usually break off and are left in the wound. Alcohol or ammonia applied to a tick's posterior will cause most ticks to release. Wait for 15–20 minutes before trying to remove tick. Engorged females drop from their host and lay their eggs on the ground or in debris. The larvae of most species feed on small animals, then become dormant until the following spring. They feed again and in about two months become adults, which in temperate climates do not feed until the next spring. It is at this stage that ticks feed also on man. Insect repellents will help to keep ticks off outdoors. After an outing in a tick-infested area, clothing should be removed and washed. Lawns or gardens can be sprayed with a contact insecticide.





STINGING CATERPILLARS have hollow hairs (setae) connected at their base to cells that secrete a poison. They may be in tufts or scattered over the body. When one of these spinelike hairs contacts the skin, the poison goes into the wound and causes either an itching or a painful swelling. Learn to recognize caterpillars that have stinging hairs and avoid touching them.

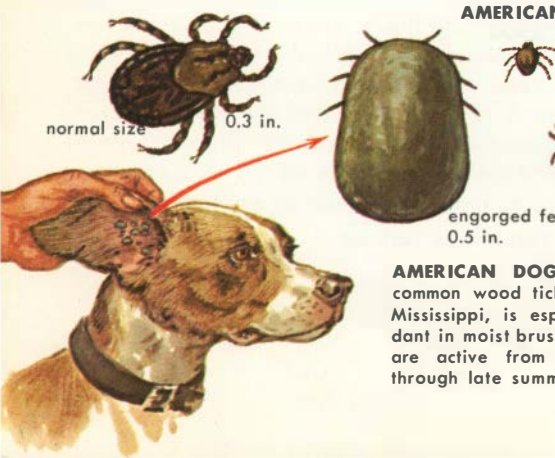
WASPS AND BEES have a stinger at the end of their abdomen. It is connected to a poison gland. These insects do not sting unless molested and are most troublesome when they nest in places where disturbing them is unavoidable. The occasional wasp or bee that gets indoors can be let out or killed. Spraying the nest with a residual contact insecticide, either as a dust or in an oil or water emulsion, will get rid of those few that become problems outdoors. It is best to spray at night, when the nest is fully occupied and the insects are not active. Stings can be soothed with ice packs or with a bicarbonate-of-soda paste. If the effects of a sting are severe, a doctor should be consulted promptly.



PESTS OF PETS, POULTRY, AND LIVESTOCK

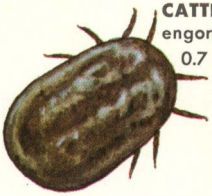
Insect pests of pets and domestic animals may be carriers of deadly diseases or of parasites that weaken the animals. Some of the diseases may be transmitted to man. Even pests that only bite or cause itching may reduce an animal's productiveness. Also, the animal's resistance to diseases may be lowered.

TICKS are more closely related to spiders than to insects. In addition to being annoyances or in extreme infestations causing anemia, these bloodsuckers carry such diseases as spotted fever and tularemia. The complex life cycle of ticks may require three years or longer. Females, after a blood meal, lay as many as 6,000 eggs, which hatch into tiny six-legged larvae, or seed ticks. Nymphs feed on mice or other small animals, and in most species only the adults attack such large animals as dogs, cats, horses, cattle, or man. Other species are discussed on p. 46.



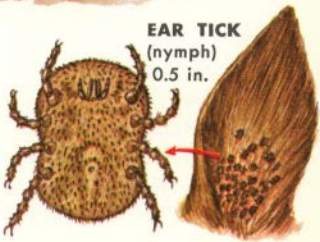
AMERICAN DOG TICK, most common wood tick east of the Mississippi, is especially abundant in moist brushlands. Adults are active from early spring through late summer.

CATTLE TICKS of southern U.S., Central and South America, Africa, and parts of Europe transmit tick fever (Texas fever or cattle fever). The disease, spread only by ticks, may be fatal in a high percentage of cases. Tiny one-celled animals passed into the host's bloodstream by the tick destroy red blood corpuscles. Sheep, horses, mules, goats, deer, and other large animals are also susceptible. Cattle ticks winter in pastures in the egg stage or as seed ticks, or they may spend the winter as nymphs or adults on host animals. A rotation use of pasture may starve seed ticks, though they can live for months without feeding. Cattle in tick-infested areas are quarantined, and are dipped (usually forced to swim through vats of insecticide solution) to kill ticks.

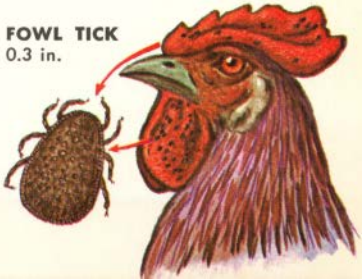


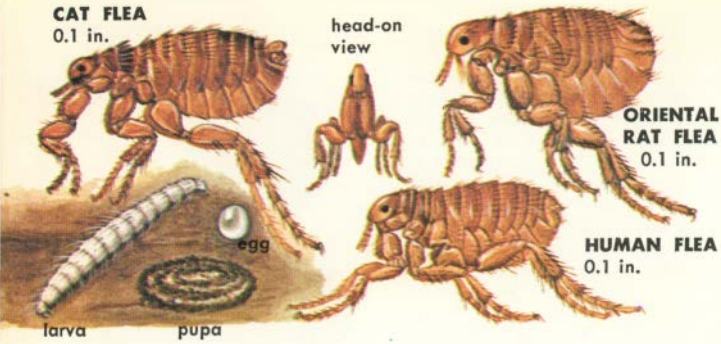


EAR TICKS, of southwestern U.S., are parasites only as nymphs, which crawl into the outer ear of sheep, horses, cattle, or other animals to gorge on blood. When full, they drop off and shed to become adults, which do not feed. Heavy infestations may cause deafness. Ear Ticks are killed with insecticides applied to the ear or head.



FOWL TICKS feed only at night, attaching to the bare skin under wings or around head. During the day they hide in cracks or crevices near roost. Worldwide in distribution in warm, dry climates, they transmit poultry diseases. Roosts are sprayed with a residual contact insecticide.



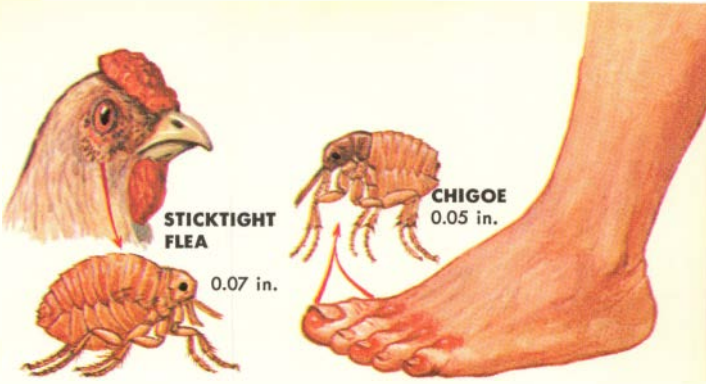


CAT FLEAS and Dog Fleas are similar in appearance and habits. Neither is restricted to the animal for which it is named, and both will bite humans.

HUMAN FLEAS are pests of man but also occur on rats, dogs, cats, and other animals. Like the Oriental Rat Flea, they may be carriers of bubonic plague.

FLEAS are wingless, bloodsucking parasites of pets, livestock, and man. A flea's body is compressed or flattened from side to side, enabling the insect to move with ease between the hairs on an animal's body. Its stiff hairs and spines (setae) project backward. When off its host, a flea travels rapidly by jumping.

An adult female flea lays small, whitish eggs on her host's body or in the host's den or nest. The eggs drop from the hair as the animal moves about or shakes itself and are commonly abundant where the animal sleeps. In about two weeks the eggs hatch into tiny, eyeless, wormlike larvae that feed on the droppings of adult fleas or other organic matter in an animal's bedding, in dust or lint, or in carpeting. Depending on the species, weather, and availability of food, the larvae complete their growth in a few days to six months or longer. When full grown, each spins a silken cocoon in which it pupates for a few days to several months before



STICKTIGHT FLEAS, of southern U.S., are flat-bodied and cling like ticks. They cluster on combs or bare skin of poultry, also on dogs, cats, and man.

CHIGOES are tropical fleas, not related to chiggers (p. 45), found rarely in southern U.S. Females burrow under the skin to lay their eggs.

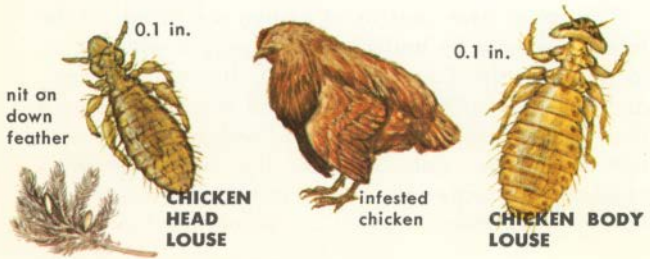
emerging as an adult. Adults can live for long periods without food, especially in cold weather. In warm weather fleas may breed outdoors in dry places.

Fleas have piercing-sucking mouthparts. The painful bites may become swollen or inflamed. Some people or animals are more sensitive to the bites than others are. Before it begins to feed, a flea usually spits out a spot of partly digested blood near the bite. It may also leave wastes. These, with whatever disease organisms they contain, may spread into the bite.

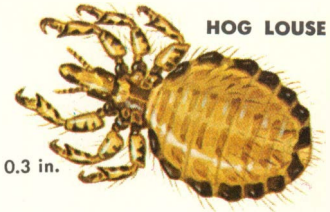
Control of fleas consists of getting the adults off the infested animal by bathing it or dusting it with a contact insecticide. Equally important, the eggs, larvae, and pupae must be destroyed and the places where they develop cleaned and treated with a residual contact insecticide. Cats, because they lick themselves regularly, are especially susceptible to insecticide poisoning. Read labels. Consult a veterinarian if in doubt.

LICE, of which there are several thousand species, are divided into two groups—biting or chewing lice, principally pests of poultry and other birds; and sucking lice, parasites on mammals. Sucking lice feed only on blood, hence may be carriers of disease. Both kinds are wingless and have poorly developed or no eyes. A louse's body is flat, and its claws are developed for clinging. At hatching, young lice look like the adults, but are smaller. Before becoming adults, they molt several times, the number varying with the species. Most lice are confined to a single or to closely related host species. Some occur only on a particular body area. Lice move to a new animal if the host dies, if they become too numerous, or by contact. Those that infest humans are sucking lice (p. 43).

POULTRY LICE feed by chewing on feathers or dried skin, causing discomfort or irritation mostly as a result of their crawling. Louse-infested poultry are poor egg layers and are susceptible to diseases. Their wings droop, and they become drowsy. Young birds may die. The Chicken Head Louse occurs mainly on the head and neck areas, Chicken Body Lice on body feathers. The lice are spread from one bird to another either by direct contact or in heavy infestations by swarming over the roost. Female lice attach eggs (nits) to down feathers with a gluey secretion. The eggs hatch in about 10 days, and the young become adults about 10 days later. Poultry lice can be killed by dusting or spraying with a contact insecticide while birds are on roost. Birds can be treated individually by dipping in an insecticide solution or by dusting.







SHEEP-BITING LICE infest both sheep and goats. Infested animals scratch and rub themselves, often causing sores. The wool on sheep becomes tangled. Contact insecticides applied as wettable powders or dips are the best means of control.

HOG LICE, related to sucking lice that infest cattle, commonly collect about the ears or in folds of skin. They never leave their host except to crawl onto another hog. Control with residual contact insecticides applied as wettable powders or as dips.

HORSE-BITING LICE chew on skin, dried excretions, or hair, causing an animal great discomfort. Lice are most commonly spread by contact with other infested animals. They are usually most abundant in winter, when an animal's hair is thickest. Treatment in the fall therefore is both a cure and a preventive. Animals should be inspected regularly in winter months and treated again if necessary. Dusts, sprays, or dips are effective, the best method depending on the number of animals to be treated. A related species occurs on cattle. Check with veterinarian about best treatment.

SHORT-NOSED CATTLE LICE are bloodsuckers, and heavily infested animals may be weakened from loss of blood. Dairy cattle do not produce as much milk; beef cattle do not put on as much weight. Controls are the same as for Horse-biting Lice, but insecticides that may contaminate milk cannot be used near dairy cattle. Burlap bags treated with an insecticide may be wrapped around a cable and stretched between two posts to give cattle a place to rub themselves and at the same time give themselves a treatment. Check with a veterinarian. A closely related species infests horses.



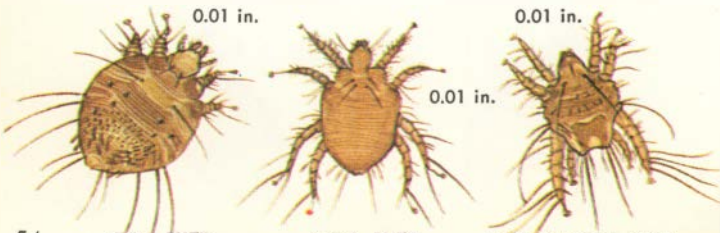


MITES, including ticks, are more closely related to spiders than to insects. Many species are barely visible to the naked eye. Some mites are free-living, others are pests of plants, and some are parasites of animals, including man (p. 45). Itch mites insert their piercing mouthparts into the skin to draw out blood or lymph. As the mites multiply, the feeding areas become larger. Scabs form, and hair or feathers drop out. As they feed, mites also secrete a poison that causes an intense itching. In most species the females burrow into the skin, making a tunnel up to an inch long, in which they lay their eggs and then die. The nymphs shed and become adults in about two weeks. Most mites never leave their host except to crawl onto another animal. Infested animals must be quarantined until cured, and their living quarters must be thoroughly disinfected, as mites are highly contagious and difficult to control. It is best to consult a veterinarian.

ITCH MITES cause an inflamed, scabby skin (mange) on dogs, horses, hogs, cattle, and other animals. The hair drops out as an animal scratches or rubs itself for relief from the itching. Infestations usually start where the skin is tender and hair is thin.

Scab Mites cause so-called "wet mange" (psoroptic scabies) of sheep, cattle, horses, and other animals. They feed on the surface, not burrowing under the skin as Itch Mites do.

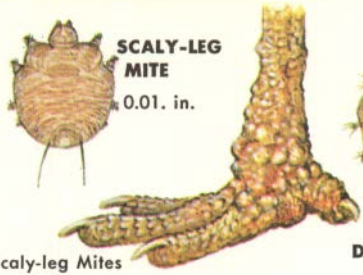
Ear Mange Mites live inside the ears of dogs, cats, and wild animals, feeding on the soft skin near the eardrum. The irritation causes the animal to run about wildly, shaking its head. Controlled by swabbing the ears with sweet oil or glycerin.



ITCH MITE SCAB MITE EAR MANGE MITE



CHICKEN MITE
0.01 in.



Scaly-leg Mites on chicken

CHICKEN MITES feed on the blood of chickens or other poultry at night, hiding about the roost during the day. Infested birds become listless and are poor egg layers. Some fowl, particularly the young, are killed. Chicken Mites are most active in spring through summer. Female mites lay their eggs in debris near the roost; nymphs reach the adult stage in about 10 days. Chicken Mites are controlled by treating the poultry house rather than the birds. Clean it thoroughly, then dust, spray, or paint with a residual contact insecticide.

FOLLICLE MITES cause mange of cats, dogs, hogs, cattle, and other animals. The long, worm-like mites burrow deep into hair follicles or into oil glands, commonly around the eyes. Red, pus-filled pimples or nodules form, often becoming infected. To prevent spread of mites in livestock, infected animals are fattened for market and killed. Pens are disinfected thoroughly. Red mange, a serious disease of dogs, is caused by a follicle mite. Consult a veterinarian.

SCALY-LEG MITES stay on the body of their host, like ticks or itch mites, tunneling under the scales of the legs or into the skin of the comb. The scales stand up, and seeping scabs form. In time the infected bird becomes unable to walk. The tiny mites can be killed by soaking the host's legs in soapy water to loosen the scales, then greasing them with oil containing 15 percent sulfur. The Depluming Mite, a related and smaller species, burrows into the skin at the base of the tail feathers. The infected bird pulls out its tail feathers. Use a sulfur dip.

HOG FOLLICLE MITE

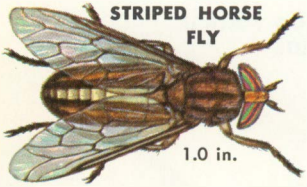


infected hog

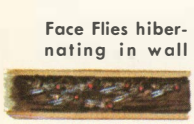
FLIES of some species bite painfully in getting their meal of blood. Those that do not bite worry or annoy animals by getting into their eyes or crawling over their body. Some flies transmit diseases. Many species, including mosquitoes, torment both man and his animals (pp. 32, 39, 40).

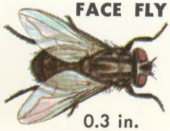
HORSE FLIES bite viciously and may also transmit such diseases as anthrax and tularemia. There are more than 100 species in the U.S. (p. 38).

FACE FLIES look like House Flies but are slightly larger. They feed on mucous secretions around the eyes and nostrils of livestock. In some areas they are pests in houses. They lay their eggs in fresh manure, in which the maggots develop and then pupate in the soil nearby. Adults commonly hibernate in the walls of buildings. There is no completely effective control for these pests, which have spread widely throughout the U.S. from Canada since the early 1950's.



Face Flies hibernating in wall

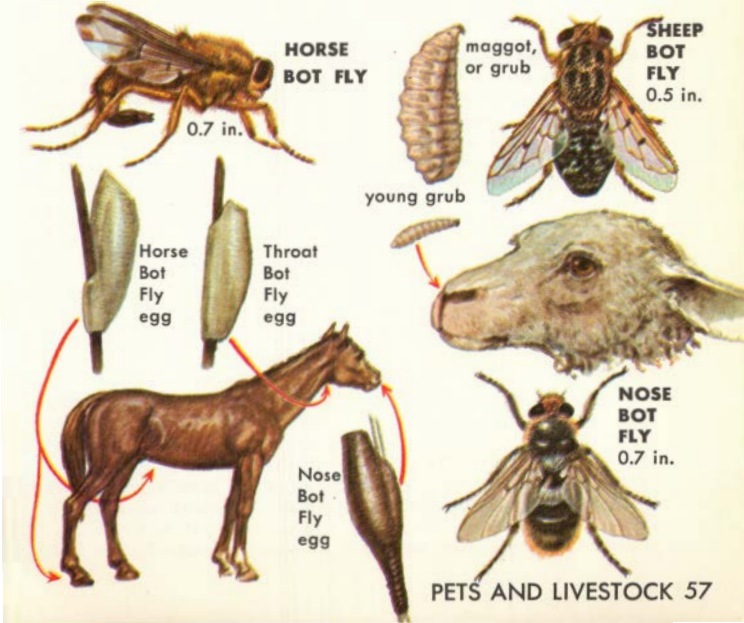


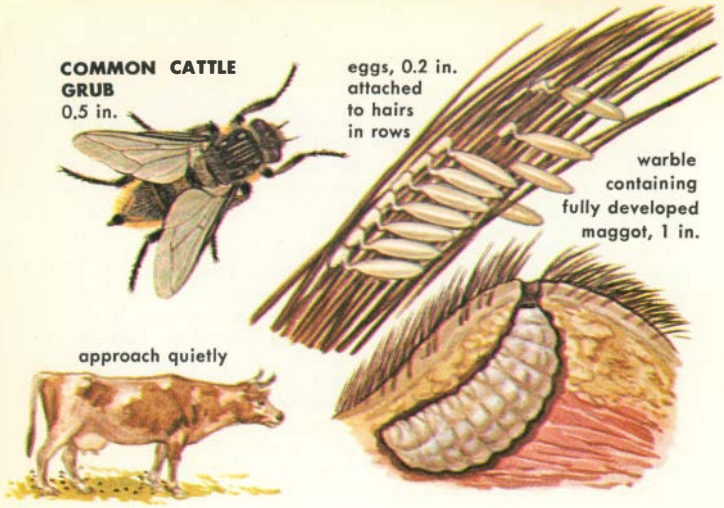


HORSE BOT FLIES glue their eggs to the hair of the hind legs or belly of horses or mules, rarely to smaller animals. Each female may lay 500 or more eggs, which hatch in about two weeks, but only if their temperature rises to 100 degrees F. or higher. This will happen if the animal touches them with its tongue. Newly hatched larvae tunnel immediately into membranes of the host's mouth. In about a month they molt and are swallowed. They feed on mucous secretions from the irritated stomach lining to which they fasten themselves. In about 10 months the maggots are full grown and are discharged in wastes. They pupate in the soil and emerge as adults in about three weeks. The Throat Bot Fly lays its eggs on hairs of the neck. The maggots emerge without special stimulation. They crawl to the mouth, often attaching to the pharynx and making it difficult for animal to swallow. Later they enter digestive tract. Eggs of Nose Bot Fly are laid near the lips and will hatch only if kept moist. Lip and throat guards help prevent bot fly infestations. Maggots in digestive tract can be killed with fumigants or with systemic insecticides given by a veterinarian.

SHEEP BOT FLIES occur wherever sheep are raised and may also infest goats or deer. Adult female flies dart rapidly about the sheep, sometimes hovering near the nostrils. Pestered sheep shake their heads, stamp their feet, or run to escape. The female deposits already hatched larvae, or maggots (not eggs), near the sheep's nostrils. She lays only a few at a time but several hundred in her lifetime. Maggots crawl into outer nasal passages, where they feed on mucus. After about two weeks they shed, becoming a size larger, and move deeper into nasal passages. Irritation of membranes by the crawling of spiny-bodied maggots causes a greater flow of mucus, which hinders breathing and may cause death in older or weakened animals. Full-grown maggots (1 in.) crawl out of nasal passage and burrow into soil to pupate, emerging as adults in about a month. In cold climates the small larvae become dormant in outer nasal passages in winter.

Control of Sheep Bot Flies is difficult, especially since it is harmful to kill the grubs in the nasal passages, where their decay will cause an abscess. Small grubs can be killed in the outer passages by irrigation with a 3 percent-Lysol solution. Pine tar applied to the sheep's snout discourages female flies from depositing maggots.





CATTLE GRUBS, or Ox Warbles, are maggots of bot flies. Infestations lower milk production of dairy cattle. The maggots cause a loss of meat in beef cattle, because the flesh must be trimmed around the grubs. Grub holes also reduce value of hides for leather. The Common Cattle Grub (also called Heel Fly) occurs throughout the U.S., the Northern Cattle Grub in Canada and all but southernmost U.S. Female Northern Cattle Grubs approach noisily and lay eggs, one at a time, on the hair of belly or legs. The cattle often stampede to escape bomber-like attacks, though the flies neither bite nor sting. The female Common Cattle Grub, in contrast, approaches victims stealthily, landing on ground nearby and backing up unnoticed to lay her eggs on the heel, or if the animal is lying down, on hair near the ground. She lays many eggs at one visit to her victim.

On hatching, the maggots (wolves) of both burrow into the skin and, over months, migrate through the tissues to the animal's back, where knotlike warbles form. The maggots develop in these cysts during the winter. The swellings are first noticeable in late fall or early winter, becoming large and pus-filled by spring. The spiny maggots feed on mucus that forms in the cysts, and they breathe through a small hole cut in the hide. In spring the maggots squeeze out through the hole and drop to the ground, where they pupate, emerging as adults in two weeks to two months.

Control is most effective if all



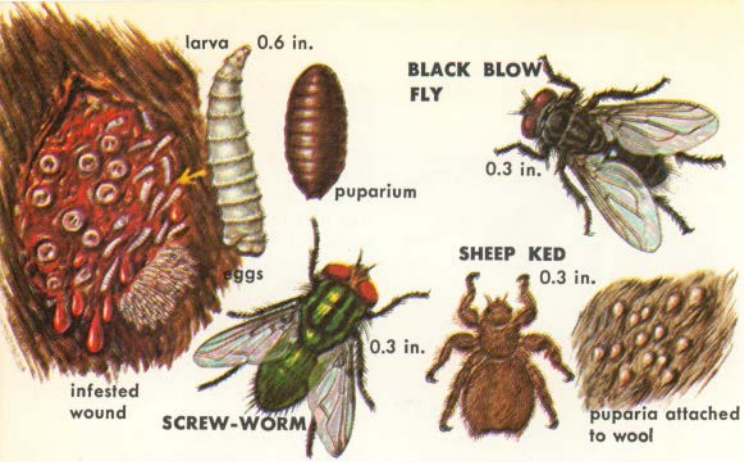
cattle owners in an area participate in an eradication program, as adult grubs can travel several miles to find victims and start reinfestations. Formerly, cattle grubs could be controlled only in the warble stage, after they had done their damage. This was a safeguard against an increased infestation the next year, however. A 5 percent rotenone dust, sprayed or applied by hand, was used to kill the maggots. The best time for these applications varies with the locality and can be learned by consulting a local agricultural agent. Better controls are possible today with systemic insecticides given orally or applied to the skin. They kill the maggots as soon as they begin to feed on their victim and before they can do damage.

HORN FLIES are common, persistent summertime pests of cattle. Horn Fly bites are painful, as the fly sucks out its meal of blood. Each cow may harbor several thousand flies, which stay with the cow constantly and torment it. Tormented beef cattle lose valuable market weight; dairy cattle give less milk.

Horn Flies lay reddish-brown eggs in fresh manure, on which maggots feed. They pupate in or beneath the dung, a life cycle requiring about 10 days in warm months.

In hot weather the Horn Flies usually rest on an animal's belly or on its shaded side. In cooler weather the flies ride on its back or sometimes on its horns. Horn Flies can be killed by spraying, dusting, or dipping cattle with a residual contact insecticide. Consult a veterinarian or local agricultural agent before applying any insecticide. Avoid especially the use of chlorinated hydrocarbons around dairy cattle, as milk may be contaminated.





SCREW-WORMS occur in warm climates, from southern United States southward through the tropics. They infest cattle, swine, sheep, goats, and deer. Females lay clusters of eggs in fresh wounds—such as the bites of the Horn Fly or scratches from thorns or wire—or in the navel of newborn animals. The maggots eat into the flesh, creating a foul-smelling larger wound that attracts Screw-worms or blow flies to lay more eggs in the rotting flesh. If untreated, infested animals will die. Full-grown maggots, with ridges of spines circling the body segments, drop to ground to pupate, completing a life cycle in about 30 days in warm weather. Control of these flies has been successful in Florida and on Curaçao, W.I., by release of millions of sterilized males (p. 23). In other areas animals are treated with an ointment, such as EQ 355, to kill maggots and allow wound to heal.

BLOODSUCKING FLIES of a number of species pester livestock. Included are the Black Blow Fly and the Secondary Screw-worm, which deposit maggots in open wounds. Infestations may become infected. Sprays are effective but use only if prescribed by veterinarian.

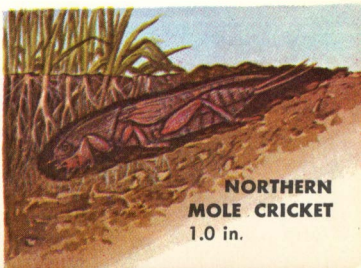
SHEEP KEDS are wingless flies commonly thought to be ticks. Adults pierce the skin of their host and suck blood, irritating the animal so that it rubs, bites, or scratches itself and ruins the wool. Sheep Keds spend their entire life on their host. Females give birth to fully developed maggots, gluing them to hair. Within a few hours the larva forms a reddish puparium. Adults emerge in about three weeks. Sheep Keds are found most abundantly on the neck or belly. Infested sheep are sprayed, dipped, or dusted with residual contact insecticides, usually after they have been sheared.

INSECT PESTS OF VEGETABLE CROPS

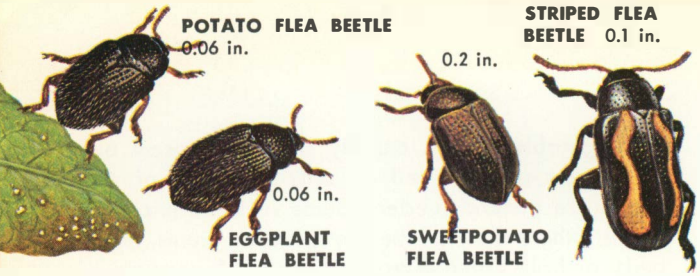
No vegetable crop is entirely safe from insect pests. Some pest species feed on only one kind of plant; others are general feeders. Some suck the juices from plants; others chew on the roots, leaves, stems, flowers, buds, or fruit. Often a crop is attacked by several pest species at the same time, and in some cases more than one stage in the life cycle of an insect pest is damaging to the same crop.

Some insect pests of vegetable crops can be controlled without the use of chemicals. Crops can be rotated so that pests depending on only one plant species do not build up a large population. Weeds, crop stalks, and other debris in which pests may breed or hibernate can be plowed under. Disking or shallow plowing in winter exposes hibernating stages to freezing temperatures. Some pests can be picked off by hand, or young plants can be covered until large enough to withstand attacks. In many cases crop planting can be timed to miss heavy infestations. Despite these precautions, chemical controls are often the only way now available to protect a crop. Chemicals must be used with great care, for they are dangerous to the person who applies them and also may be absorbed by the vegetable or remain as a poisonous residue.

MOLE CRICKETS, abundant in warm climates, use their stout paddlelike front legs for burrowing. They disturb the roots of young plants and also feed on them. Mole Crickets can be killed with contact insecticides or poison baits applied to the soil before planting.

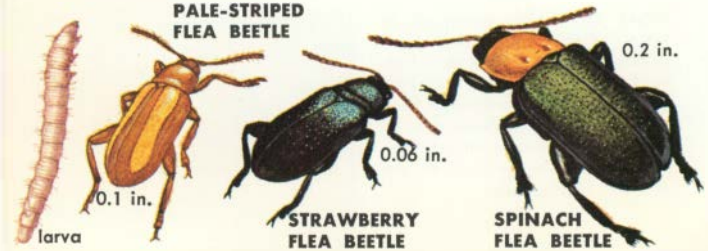


NORTHERN MOLE CRICKET 1.0 in.

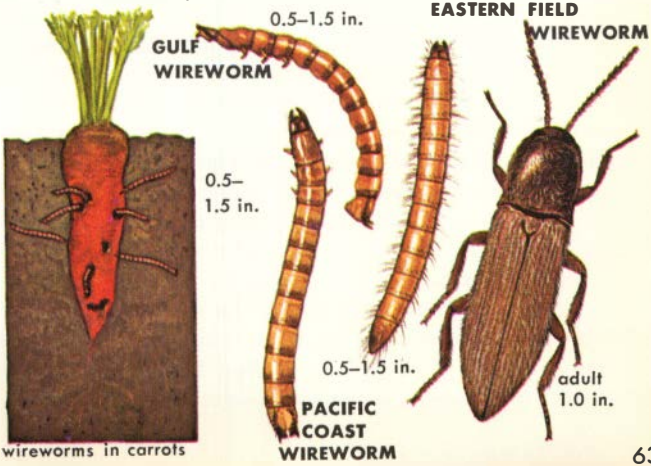


FLEA BEETLES chew small, round holes in leaves, giving a plant the appearance of being peppered with shot. Grubs (larvae) of some species feed on leaves or stems, others on the roots. The many species of flea beetles (so called because of their enlarged hind legs for jumping) feed on a variety of plants, but many, as indicated by the specific names, occur on only one kind or on closely related plants. Most species overwinter as adults beneath debris and thus get an early start in spring. Flea beetles are especially damaging to seedlings, and the holes they eat in the foliage are entry avenues for diseases. Usually there are two generations a year.

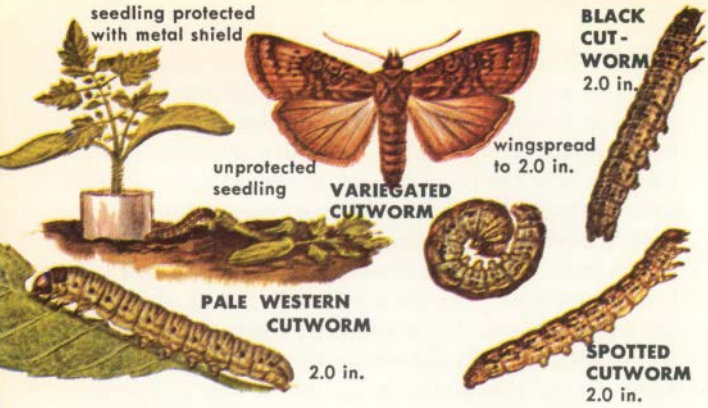
Eliminate places where the beetles can hibernate by plowing under weeds or plant stalks. Infested plants can be dusted or sprayed with contact or stomach-poison insecticides to kill adult or immature stages. Do not use insecticides immediately before an edible crop is ready for harvest because of poisonous residues. Follow directions carefully.



WIREWORMS are the grubs, or larvae, of click beetles. Those of pest species feed on the underground stems, roots, or tubers of such plants as carrots, beets, potatoes, onions, turnips, beans, and corn. Wireworms may be especially abundant in land recently in grass, though some species live exclusively in cultivated land. Adult female beetles lay their eggs in the soil, and the larvae (wireworms) migrate vertically in the soil, staying at the level where the temperature and moisture are most comfortable for them. Some species become full grown in two years; others do not mature for as long as six years. They change into pupae in the soil. A few weeks later they become adults but do not emerge until following spring. Cultivation from midsummer until freezing weather destroys many larvae and pupae. Infested soil can be fumigated, which kills the worms but gives no lasting protection, or treated with a contact insecticide. Insecticides absorbed by root crops may cause objectionable odors or leave poisonous residues. Check for best method in your area.



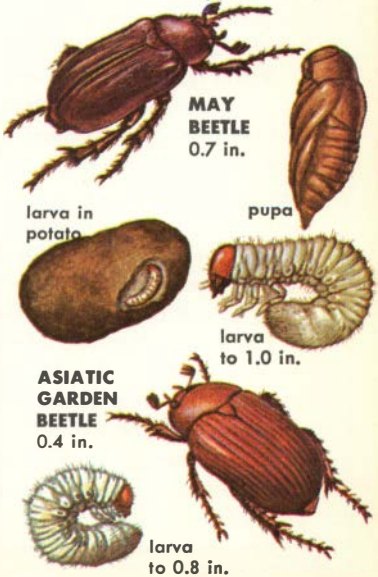
wireworms in carrots



CUTWORMS are the fat larvae of a large family of dull-colored, medium-sized moths. More than two dozen species are pests of field and garden crops. Cutworms are classified by their method of feeding—whether underground, at the surface, or above the ground. The most damaging to vegetable crops are species that cut off plants at the surface. Cutworms feed mainly at night. During the day they rest in the soil, coiled in a ball. When full grown, they burrow deeper to pupate. They may emerge as adults in a few weeks or may overwinter as pupae. In warm climates cutworms have several generations a year. Collars of tin cans with the ends removed or of stiff cardboard inserted at least an inch into the soil and sticking above the surface about two inches will protect young plants. Deep plowing or spading in late summer or fall destroys eggs and also exposes the pupae. Poison baits used for grasshoppers (p. 99) are also useful. The soil can be treated with contact insecticides such as chlordane or DDT, but use precautions as noted for Flea Beetles and Wireworms (pp. 62–63) when applying to edible crops.

WHITE GRUBS, the larvae of several species of beetles known as May Beetles or June Bugs, are widely distributed in the U.S. but are most abundant in the Midwest and South. Adult beetles feed on the foliage of trees and are commonly attracted to lights. Females lay their eggs on the ground, commonly in grassy areas. The grubs feed on roots, burrowing deeper into the soil in winter and remaining dormant until spring. Depending on the species, a second, third, or even a fourth summer may be spent as grubs before they pupate. They transform into adults in the fall but do not emerge until spring. Soil infested with white grubs can be treated with a contact insecticide before a crop is planted. In late summer or fall, soil can be turned to expose grubs and pupae to weather and predators.

ASIATIC GARDEN BEETLES are introduced pests that feed on a great variety of plants, including many garden vegetables. First found in 1922 in New Jersey, they have since spread north in coastal states as far as Massachusetts and south to the Carolinas. Apparently they survive only where there is heavy summer rainfall. Asiatic Garden Beetles winter as grubs in the soil, burrowing 8 to 10 inches deep. In spring they move back to the surface to feed on roots, then pupate in late spring or summer. Adults, which look like small, hairy May Beetles, appear in midsummer and feed on foliage until frost. Females usually lay their eggs in grassy or weedy soil. Soil or plants infested with adults or grubs can be treated with a contact insecticide. Adults are attracted to light traps.

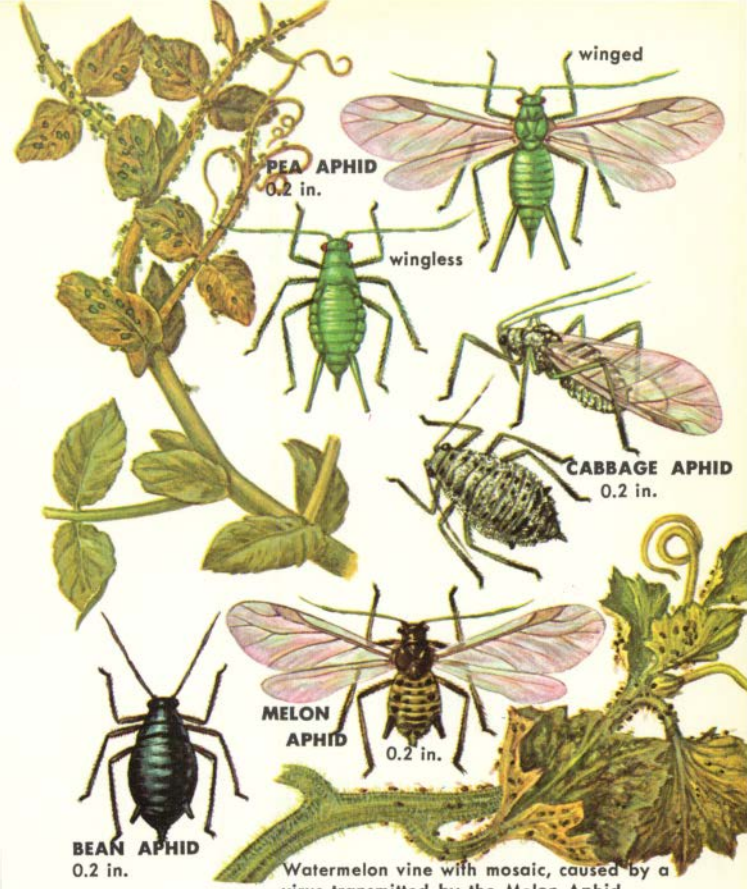


APHIDS, OR PLANT LICE, are small (average 0.2 in.), soft-bodied insects that feed on plants by sucking their fluids or sap. They pierce stems, leaves, buds, roots, and fruit with the slim, needle-sharp stylets in their beak. In abundance, aphids may cause leaves to curl or may stunt a plant's growth and stall its production of flowers or fruit. Eventually the plant may die. Aphids also introduce fungus, bacterial, and virus diseases that can be as damaging as the aphids.

Aphids expel from the end of their abdomen a sticky, sweet substance called honeydew, a favorite food of some species of ants. These ants move the aphids to productive plants and take them into their nests below ground to protect them at night or when the weather is bad (p. 100). Black molds grow on honeydew that drops to the ground beneath plants where aphids are feeding.

In the typical life cycle of aphids that live in temperate climates, winter is passed in the egg stage, glued to the stem or to other parts of plants. Nymphs that hatch from the eggs the following spring grow rapidly to become wingless adults, called stem mothers. Stem mothers give birth to their young, holding the eggs inside their body until they hatch. Within about a week these aphids produce young in a similar manner. More than a dozen generations appear in a short time, forming a feeding cluster on the plant. At intervals some or all of the young develop wings and migrate to other plants, starting new colonies. In some species the winged stages settle on plants of the same kind; in others they always settle on different kinds of plants. In autumn males and females are produced, and the females lay fertilized eggs that overwinter. In warm climates reproduction is continuous.

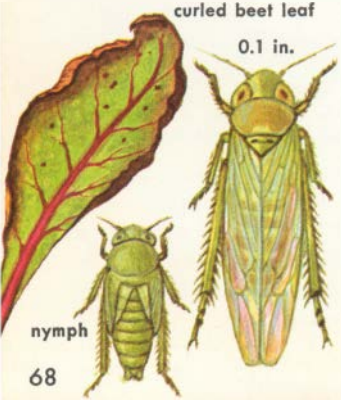
Aphids are eaten by birds, preyed on by various lady



Watermelon vine with mosaic, caused by a virus transmitted by the Melon Aphid.

beetles, and parasitized by wasps. Chemical controls may be necessary, however, to protect crops when aphids are abundant. Contact insecticides applied as dusts or sprays are effective. Precautions regarding the use of these poisons should be followed, as noted on labels or advised by agricultural agents.

LEAFHOPPERS are small, active insects that damage plants by sucking sap from their leaves. The leaves curl, due either to the loss of sap or possibly to a toxin introduced by the leafhoppers as they feed. Some leafhoppers also spread virus diseases. When disturbed, adult leafhoppers hop into the air and fly away, their wings appearing white in flight. The wingless nymphs run sideways to dodge out of sight on the opposite side of a leaf. Like aphids, leafhoppers excrete from the end of their abdomen a sticky, sweet substance called honeydew. A population of several million leafhoppers may build up on plants on an acre of land in favorable conditions. Contact insecticides sprayed or dusted on the plants will kill the leafhoppers, but the insecticide must reach insects feeding on the underside of the leaves. Do not use insecticides after edible parts of plant have formed, because poisonous residues may remain. Local county agent can give information on best times and the proper dosages of insecticides. To guard against the spread of a virus disease by these pests, it may be necessary to control the leafhoppers on their wintering plants.

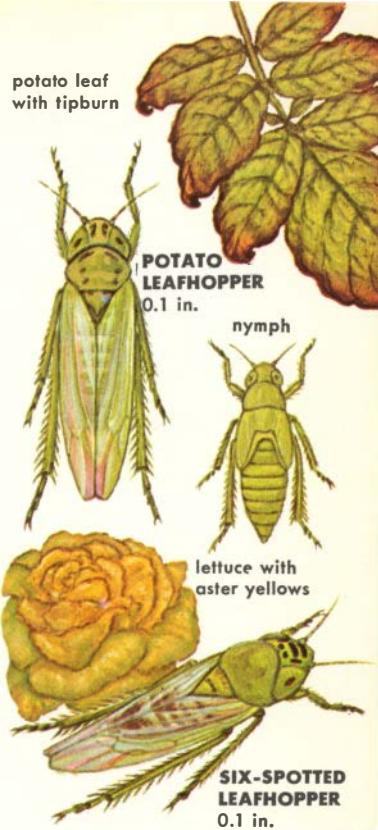


BEET LEAFHOPPERS are pests in western U.S., ranging east to Illinois. They transmit the virus causing curly top, a disease of sugar beets, beans, spinach, peppers, squash, and other vegetables. Adults winter on wild plants, and in early spring females lay eggs in stems or on the leaves. This generation feeds and matures on wild plants. The second generation invades cultivated crops. As many as five generations may be produced in a season.

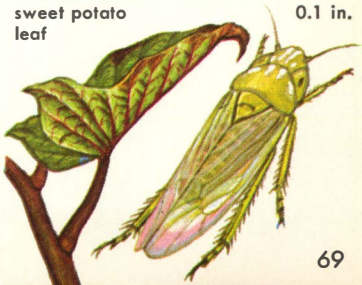
POTATO LEAFHOPPERS are damaging pests of potatoes east of the Rocky Mountains. They winter in southern states, migrating as far northward as Canada in spring and summer. Potato Leafhoppers commonly attack young bean plants before appearing on potatoes, because young bean plants apparently contain a greater amount of sugar than do the young potato plants. Females lay their eggs in the stems of leaves, depositing two to three eggs a day over three to four weeks. The nymphs hatch in 10 days and are full grown in about two weeks. Tipburn, or hopperburn, is caused by the feeding of Potato Leafhoppers. First a triangular brown spot appears on a leaf tip; then similar spots show elsewhere, always at end of veins. Eventually entire leaf turns brown and curls.

SIX-SPOTTED LEAFHOPPERS transmit the virus disease called aster yellows. In diseased plants, the young leaves turn yellow, and older leaves become curled and reddish. Lettuce, celery, tomatoes, onions, and carrots are common vegetable crops injured by aster yellows. The Six-spotted Leafhopper winters on weeds or flowers, spreading in spring.

SOUTHERN GARDEN LEAFHOPPERS, similar and closely related to the Potato Leafhopper, range as far north as New York, though they are most abundant in southern states. They infest ornamentals as well as vegetable crops.



SOUTHERN GARDEN LEAFHOPPER 0.1 in.





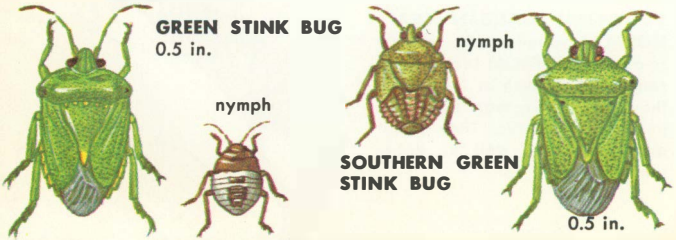


HARLEQUIN BUGS are pests of cabbage, turnips, radishes, and related plants. They have spread from Mexico through most of the U.S. Females lay barrel-shaped eggs on the underside of early planted crops. Nymphs, which hatch in about a week, may kill young plants by sucking out sap. In the South they breed year around; in the North adults hibernate under vegetation.

STINK BUGS do damage, both as adults and as nymphs, by sucking sap from plants and causing them to wilt. Peas, beans, or fruit on which stink bugs have fed become pimpled or malformed. The bugs also give off a strong odor that may be detected on edible parts of plants over which they have crawled. The wingless nymphs generally resemble the adults, though in some species they differ in color. In both, the triangular area, or scutellum, is large and conspicuous. Infested plants can be sprayed with contact insecticides, but this should not be done after edible parts are formed. The bugs are large enough to be picked off by hand.

GREEN STINK BUGS commonly feed on beans, causing pods to fall before they are fully formed. In the South they are also pests of cotton.

SOUTHERN GREEN STINK BUGS are most abundant in southeastern U.S. They feed on most legume crops and on many garden vegetables.



TARNISHED PLANT BUGS feed on more than 50 species of cultivated plants, including beets, celery, and other garden vegetables. A toxin injected into the plant as the bug sucks out its sap deforms the leaves, stems, or fruit. Both adults and nymphs can be killed with contact-insecticide sprays or dusts, but do not use poisonous insecticides after the plant begins to form edible parts. In temperate climates, where the adults hibernate in winter, weeds or similar hiding places should be destroyed.



SQUASH BUGS injure pumpkins, cucumbers, squash, and related plants, first causing the leaves to wilt and then the vine to turn black. Crushed Squash Bugs give off an odor similar to a stink bug's. Squash Bugs are difficult to control, as squash plants are burned by many contact insecticides. Adults can be picked off plants by hand. Leaves that show egg-laying scars should also be removed. Adults may congregate under boards placed between crop rows. In the fall, get rid of all debris under which adults may hibernate.





EGGPLANT LACE BUG
0.1 in.

LACE BUGS have a broad thorax and transparent wings with an attractive lacelike pattern. Lace Bugs are known to carry a virus disease of sugar beets, and their feeding in large numbers stunts a plant's growth. Contact insecticides are an effective control.

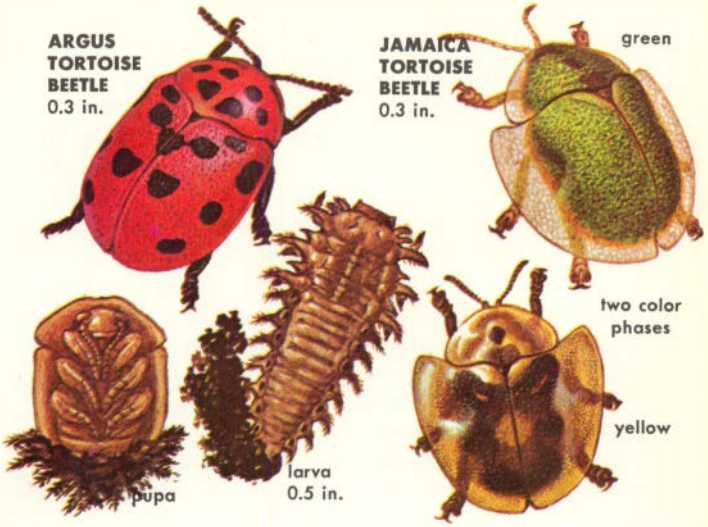
THRIPS are slender insects with stout, cone-shaped mouthparts. They rasp or scrape the stem or leaf of a plant, then suck out the sap that flows into the wound. If an infestation is heavy a plant's growth is slowed; edible parts of vegetables are poorly formed. Thrips are known also to transmit a virus causing wilt. Most thrips' legs end in a bladder-like swelling that helps them in crawling over smooth surfaces. Most species of thrips have narrow, bristle-like fringed wings. Nymphs are wingless. Of the several thousand species, only a few are pests of specific plants.



ONION THRIPS
0.04 in.

detail of head

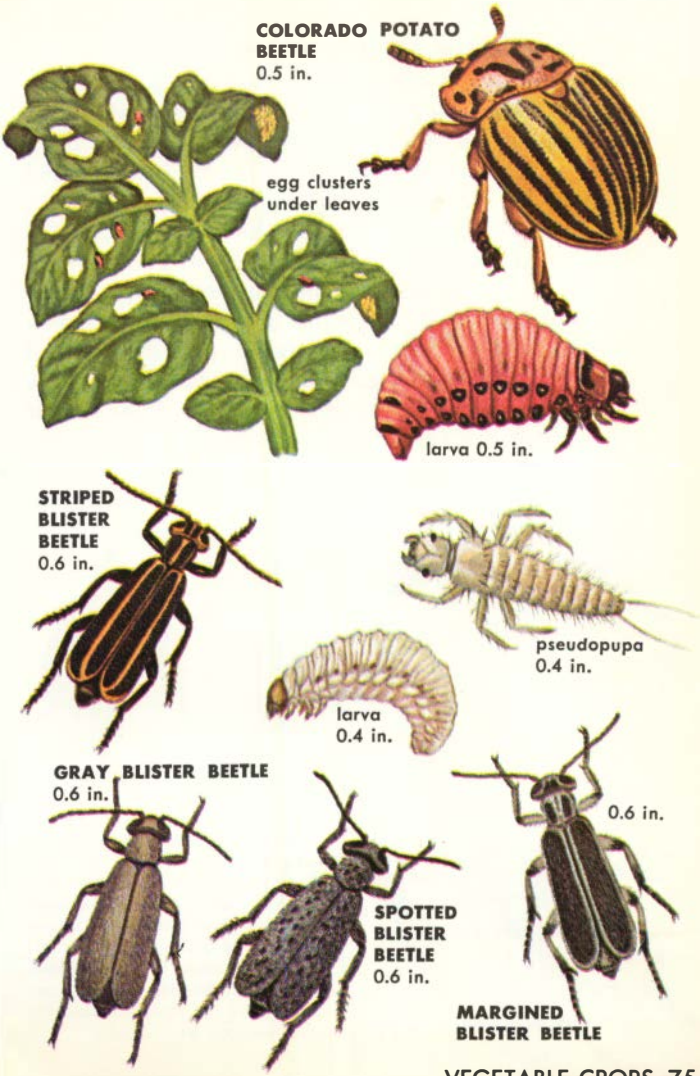
ONION THRIPS are especially injurious to onions but feed also on carrots, beans, peas, and other vegetable crops. In winter they hibernate but begin feeding on young plants in early spring, producing a new generation approximately every two weeks in warm weather. Onion leaves turn pale to white, a condition known as silver top. Well-cultivated crops may grow faster than the thrips can do damage. In the fall, bury debris under which thrips might hibernate. Contact insecticides will kill thrips, but they crawl deep into leaves and are hard to reach.



TORTOISE BEETLES often go by the name of Gold Bugs because of their metallic colors. Adult beetles hibernate under leaves or other debris on the ground. They emerge in late spring, and the females lay eggs on the stems or underside of leaves of sweet potatoes and other plants of the morning-glory family. The larvae are spiny and covered with a dirty-looking mass consisting of their shed skins mixed with silk and excrement. They feed on the underside of leaves and do the greatest injury to young plants. When full grown the larvae (sometimes called peddlers) form spiny pupae attached to the underside of a leaf. The adult beetle emerges in about a week. Both adults and larvae can be killed with either stomach-poison or contact insecticides applied as dusts or sprays. Cleaning up vines in the fall destroys the hibernating place of the adults.

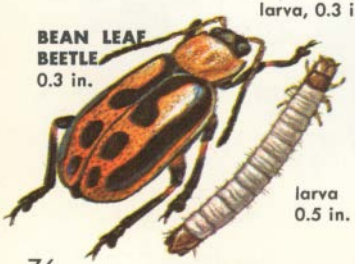
COLORADO POTATO BEETLES are pests principally of potatoes but also attack tomatoes, peppers, and other garden vegetables. They occur throughout the United States and in Europe, having spread in the 1800's from a limited range on the lower slopes of the Rockies. There they fed on the buffalo or sand bur, a plant related to the potato. Adults emerge from hibernation in early spring and begin feeding on young plants. The females lay their eggs on the lower surface of the leaves. The larvae feed on foliage for two to three weeks, then pupate in soil. Adults emerge in about two weeks and start cycle again. Two generations in a season are usual; sometimes there are three. Both adults and larvae (grubs or slugs) can be picked off by hand, or plants can be sprayed or dusted with a contact or stomach-poison insecticide. Start treatment as soon as beetles appear.

BLISTER BEETLES, or Old-fashioned Potato Bugs, eat the foliage of potatoes, beans, peas, and other vegetables. Only the adults are damaging. Females lay their eggs in the soil, and the burrowing larvae feed on grasshopper eggs. With each of its four molts the larva's legs and mouthparts become smaller compared to the remainder of its body. Winter is passed in an inactive pseudopupa stage. Most species molt the following spring, and the larva becomes active for a short time before entering the true pupa stage. Adults emerge in midsummer. Blister beetles can be brushed into pans of kerosene. Do not touch the beetles with bare hands, as they give off a blistering secretion. The beetles can also be herded along crop rows and trapped in steep-sided ditches. Can be killed with stomach-poison or contact insecticides (except arsenic compounds).

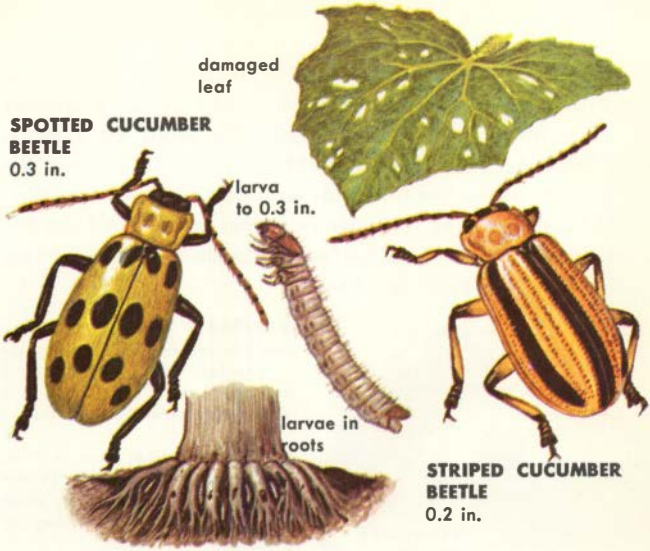

COLORADO POTATO BEETLE
0.5 in.
egg clusters under leaves
larva 0.5 in.
STRIPED BLISTER BEETLE
0.6 in.
pseudopupa
0.4 in.
larva
0.4 in.
GRAY BLISTER BEETLE
0.6 in.
SPOTTED BLISTER BEETLE
0.6 in.
0.6 in.
MARGINED BLISTER BEETLE

MEXICAN BEAN BEETLES and their larvae feed on the foliage of bean plants, eating away the lower surface and leaving only a skeleton of a leaf. When the beetles are abundant, they feed also on bean pods and stems. Native to southwestern U.S. and Mexico, the beetle has spread throughout the U.S., except along Pacific coast. Adult beetles hibernate beneath vegetation and begin feeding in early spring. The eggs, laid on the underside of bean leaves, hatch in about two weeks. When full grown, about a month later, the larvae fasten themselves to the underside of a leaf, shed, and become pupae. Adults emerge in about two weeks and start a second cycle. Three or four generations are common in warm climates. Insecticide sprays or dusts such as rotenone are applied to underside of leaves where insects feed. After beans are harvested, plants should be buried or burned.



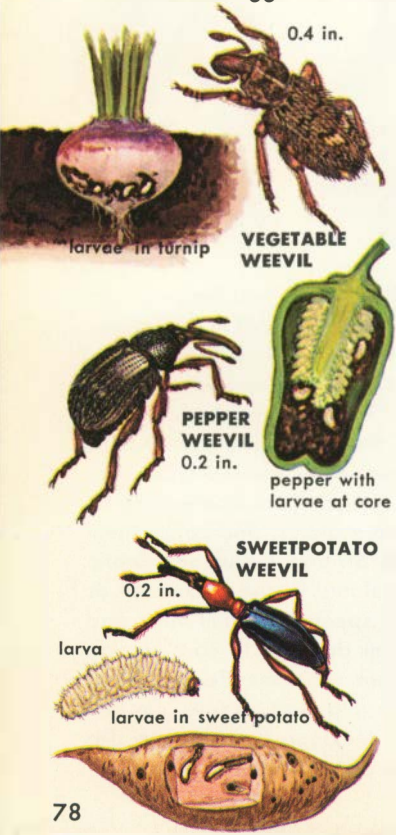


BEAN LEAF BEETLES are most abundant in southeastern U.S. but occur also in midwestern and eastern states. Adults chew holes in bean-plant leaves; the larvae feed underground on the roots or on the stems at the soil line. Bean Leaf Beetles can be controlled by the methods used for the Mexican Bean Beetle.



CUCUMBER BEETLES, both Spotted and Striped, are general feeders as adults. They chew holes in the foliage and eat on the stems. Adult beetles come out of hibernation in early spring, and females lay their eggs in the soil at the base of plants. These hatch into the worm-like larvae which bore into the roots, where they feed and become mature by midsummer. Spotted Cucumber Beetles are also known as Southern Corn Rootworms, as the larvae bore out young corn plants, and cause them to break off. Larvae of the Striped Cucumber Beetle feed only on the roots of plants in the cucumber or melon family. Adults of both species transmit virus and bacterial diseases. To prevent damage to corn, spring plowing and late planting are recommended, or treat soil with insecticides before planting. Adults can be killed by methods used for Mexican Bean Beetle. Do not use sulfur compounds on cucumber or melon vines.

WEEVILS are a large family of beetles with long, usually down-curved snouts that may in some species be as long as the beetle's body. The snout, an elongation of the head, has the beetle's small chewing mouthparts at its tip; the antennae are located along its sides. The snout is used to puncture leaves, stems, or fruit, for feeding beneath the surface, and also to make holes in which the eggs are laid.

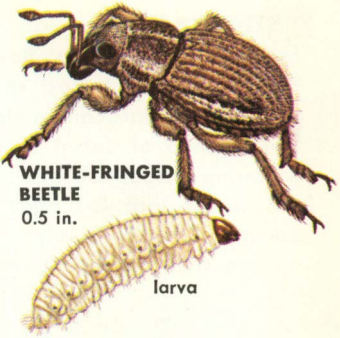


VEGETABLE WEEVILS are dormant in summer but become active in fall. Grubs feed at night on many vegetables. Do not spray vegetables to be eaten.

PEPPER WEEVILS, from Mexico, feed inside the buds or in the peppers, causing them to drop off. Several generations may be produced every year.

SWEETPOTATO WEEVILS are pests only in the Gulf states. Adults lay their eggs singly in holes on the stems or in the sweet potatoes, and for 2 or 3 weeks the grubs feed and grow either in the vines or in the potatoes. They become pupae in the cavity hollowed by their feeding and emerge as adults in about a week. The adults also feed on the leaves and stems of the sweet potato vine. Pulling dirt high around vines helps to prevent weevils from reaching the potatoes. Plants can be treated with a contact insecticide before planting. After an infestation, burn vines and destroy all infested sweet potatoes. Do not replant sweet potatoes in same field or within one mile of infestation for a year.

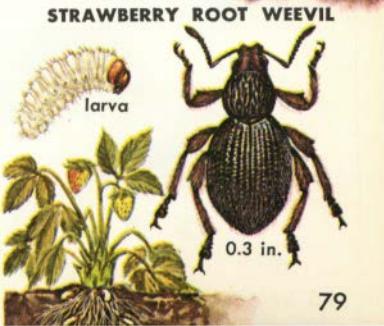
WHITE-FRINGED BEETLES, from South America, are general garden pests of southeastern U.S. Adults appear from May through August and feed sparingly. The females reproduce without mating and lay their eggs in sticky masses of 50 or more on rocks, sticks, or stems. The larvae burrow into the soil, where they feed on roots or underground stems. They winter as grubs, forming pupae in the spring. Adults cannot fly (hard outer wings are fused) and can be trapped in steep-sided ditches. Treat soil with a contact insecticide to kill grubs or adults as they emerge.



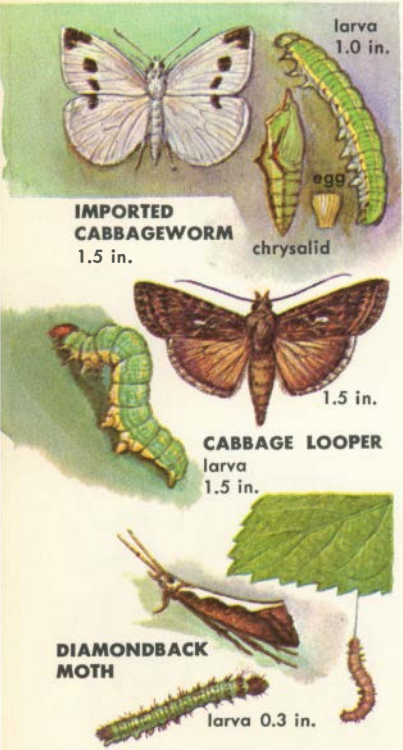
CARROT WEEVILS damage carrots, celery, parsnips, and related plants. The grubs cut irregular furrows in the roots or may tunnel inside the roots or stems. In winter adults hibernate beneath debris and lay their eggs in early spring. Two and sometimes three generations are produced every season. Early spraying of plants with insecticide will kill adults. Because they feed inside roots or stems, grubs are difficult to kill.



STRAWBERRY ROOT WEEVILS are widely distributed in the U.S. and Europe. In the grub stage they feed on the roots and crown of strawberry plants, which become stunted or die. Adult weevils often hibernate in the crown of the plant; the larvae burrow deep into the soil. Rotate plants to new beds regularly to prevent pest buildup.



CATERPILLARS, the larvae of butterflies and moths, feed on leaves, stems, flowers, or fruit. Some species tunnel inside, but most species eat from the outside. Large caterpillars can be picked by hand and destroyed. Fall cleanup of debris and turning the soil to expose wintering stages are effective. Among natural controls are wasps that lay eggs on the caterpillars, which become food for wasp larvae. Both stomach-poison and contact insecticides are effective controls.



IMPORTED CABBAGEWORMS are primarily pests of cabbage-family plants but may at times feed on other garden vegetables, chewing holes in leaves. They hibernate as pupae and emerge as the familiar White Cabbage Butterflies. Several broods a year in warm climates.

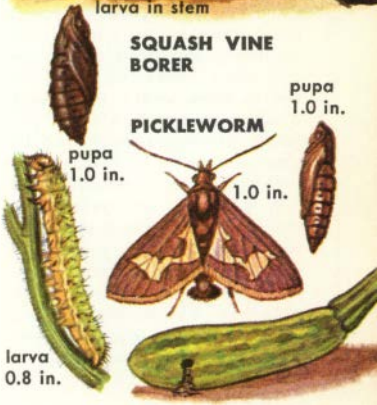
CABBAGE LOOPERS, common throughout the U.S., feed on the underside of the leaves of cabbage and related plants. They crawl with a distinctive looping, or measuring-worm, movement. Cabbage Loopers winter as pupae attached to the underside of a leaf and emerge in spring as brown moths. Usually there are two or more generations a year.

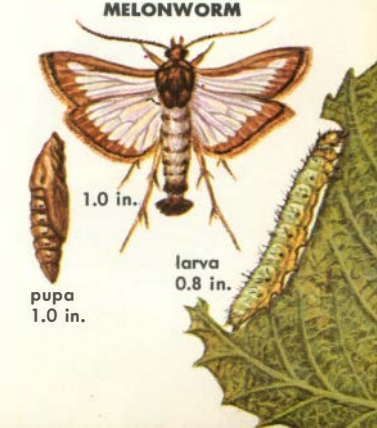
DIAMONDBACK MOTH caterpillars eat small holes in the leaves of cabbage and related plants. Though seldom abundant, there may be local outbreaks. When disturbed, the worms wriggle rapidly and drop from the plant, hanging by a silken thread. Adult moths winter on the leaves of plants or in debris.

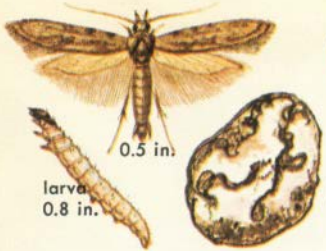
SQUASH VINE BORERS eat out the center of the stems of squash vines, causing them to wilt. They also attack pumpkins and, less commonly, cucumbers and muskmelons. Squash Vine Borers winter in the soil in silken cocoons. The moths, active during the day, lay their eggs at the base of plants, and the larvae burrow into the stems. Like other borers, these worms are hard to control because they work inside stems. Presence can be detected by the excrement (frass) pushed from hole in vine. Worms should be cut out by a lengthwise slit. After crop harvest, turn soil to expose the cocoons.

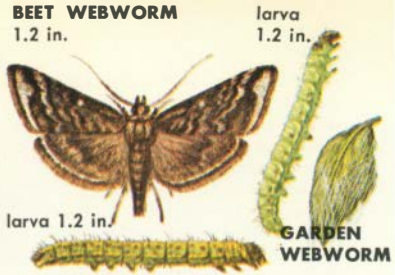
PICKLEWORMS bore into squash, muskmelons, and cucumbers, causing them to rot. Full grown after about two weeks of feeding, the worms roll the edge of a leaf over themselves and spin a thin layer of silk to form a pupa. Some cocoons remain attached to the plant; others drop to the ground. Adults emerge in about 10 days. Pickleworms reach a population peak late in the season; therefore, crops planted early are damaged least. Three or four generations are produced in a season. The related Melonworm feeds mostly on foliage. Both species are abundant pests in southern states, and the Pickleworm ranges as far north as Canada. To protect melons, squash are planted between the rows to collect the worms, which prefer the squash to the melons.









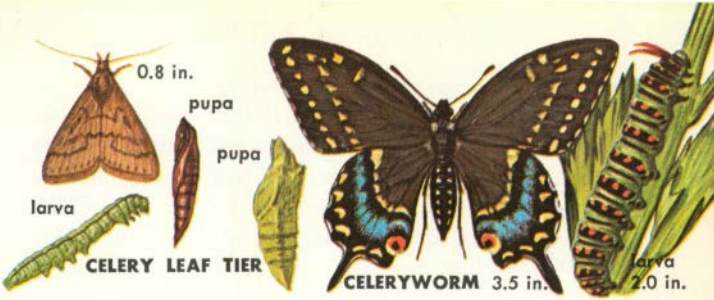


POTATO TUBERWORMS that hatch early in the season feed on leaves and stems of the potato plant. When full grown, in two to three weeks, each spins a silken cocoon in which it pupates on the ground. Adults emerge in about 10 days. Worms that hatch later in season tunnel into potatoes. Six generations may be produced in a year. Pull soil high around plants, as worms will not burrow deep. Cut, burn infested vines. Store potatoes where night-flying moths cannot lay eggs on them. Fumigate infested potatoes.

WEBWORMS of several species are general feeders on garden vegetables. In large infestations the worms migrate from one food plant to another. Webworms winter as larvae in silk-lined tubes and enter the pupa stage in the spring. Adults of the first generation emerge from March through June. The feeding worm spins a silken web that pulls together the edges of a leaf and anchors it to the ground. The worm hides in dirt at bottom of funnel. Can be killed with stomach-poison or contact insecticides.



TOMATO HORNWORMS, also pests of tobacco, potatoes, and other related plants, pass the winter as hard-shelled pupae. The adults are large hawk moths that feed harmlessly on the nectar of deep-throated flowers such as petunias. Female moths lay their eggs on leaves of tomato plants, and the larvae feed ravenously, becoming full grown in about a month. They burrow into the soil to pupate. Two generations may be produced in a year in warm climates. The Corn Earworm (p. 109) and a number of cutworms (p. 64) burrow into tomatoes and feed inside.



CELERY LEAF TIERS infest celery, spinach, beets, and related plants, feeding on the leaves and tender growing parts and covering them with webs. When full grown, the worm pulls together the edges of a leaf and fastens them with silk. It pupates in a silken cocoon inside this roll. A complete life cycle takes about a month and a half, and in warm climates there may be several broods a year. Celery Leaf Tiers can be controlled with stomach-poison or contact insecticides, which should not be used on edible parts of plants.

CELERYWORMS feed on the leaves of celery, parsnips, carrots, parsley, and related plants. When disturbed, the caterpillars protrude two orange horns near their head. The horns are soft and harmless, but at the same time the worm gives off a sweetish odor that apparently discourages predators. The butterflies (Black Swallowtails) overwinter in southern states. In the North the worms enter the pupa stage in winter. Celeryworms are seldom serious pests, and as they are large, they can be picked off the plants by hand.

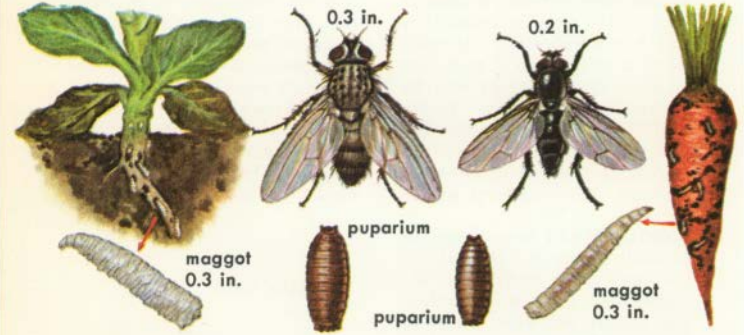
WOOLLYBEARS are orange- or yellow-and-black caterpillars that feed on all kinds of garden vegetables. They may produce two broods per year. None of the several species are serious pests of particular plants. Some species hibernate as larvae, others in a cocoon made partly from their body hairs. They can be hand picked or killed with either contact or stomach-poison insecticides. The caterpillars roll into a ball when disturbed. In folklore the width of the bands on the caterpillar's body is said to forecast the winter—the more black, the colder the winter.



MAGGOTS (larvae) of some flies bore into stems or roots. Others, called leaf miners, feed on the tissues of leaves. The larvae pupate in the soil, and the adults lay their eggs on stems or leaves. Use contact insecticides to kill the adults, and stomach-poison insecticides for the maggots. Do not apply poisonous insecticides to plant parts that are to be eaten.

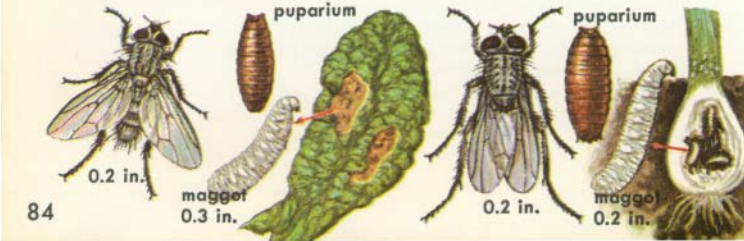
CABBAGE MAGGOTS are pests in northern U.S., where they feed on the roots of cabbage, turnips, radishes, broccoli, and similar vegetables. Infested plants wilt and may die. Several generations are produced in a year.

CARROT RUST FLIES lay their eggs at the base of plants, and the maggots work into the soil to feed on roots. Entire root systems of carrots, celery, parsnips, and related plants may be destroyed by these maggots.



SPINACH LEAF MINERS infest beets, spinach, and other leafy vegetables, causing yellowish channels in leaves.

ONION MAGGOTS, especially bad pests in wet years, tunnel into onion bulbs. They are most abundant in northern states.





MITES, more closely related to spiders and ticks than to insects, are major pests of plants and also of man (p. 45) and his pets and domestic animals (pp. 54–55). Plant feeders suck the sap from leaves or tender parts of stems, causing them to become discolored. The injury weakens and may kill young plants. Many species spin, on the undersurface of leaves, a fine web containing their eggs and shed skins. Mites are most damaging in hot, dry weather, when a life cycle may be completed in as short a time as one week. Mites can be reduced in numbers by getting rid of weeds or other debris in which they pass the winter as adults or in the egg stage. Infested plants can be sprayed with a contact insecticide. Special miticides are also available. Consult a local agricultural agent.

SLUGS AND SNAILS are mollusks that sometimes feed on the foliage of vegetables. The damage may be mistaken for the feeding of insect pests. Slugs lack shells. Both slugs and snails leave a slimy trail. They usually feed at night and hide under debris during the day. Spread poison baits of calcium arsenate or metaldehyde mixed with bran, molasses, and water.



PESTS OF FLOWERS AND SHRUBS

Some insect pests of flowers and shrubs feed on a wide variety of plants, including vegetable and field crops. Others attack only one kind of plant. A greater range of chemicals can be used to kill insect pests on flowers and shrubs than can be risked on food plants, but follow carefully the directions for applying insecticides. Nearly all of these poisons are dangerous to people, pets, and domestic animals as well as to insects.

SCALES AND MEALYBUGS are among the most damaging of all insect pests of flowers and shrubs. Males of both mealybugs and scales can fly; females are wingless. Female mealybugs have legs and crawl slowly over stems and leaves as they feed. Soft scales, though legless, can move sluggishly but seldom do. Female armored scales, covered with a tough scale of wax mixed with shed skins of the nymph stages, fasten themselves permanently to a plant. A mealybug's body is covered with a cottony mass of wax that forms thread-like extensions. Scales and mealybugs suck the sap from leaves or stems, sometimes causing plants to wilt. If infestations go unchecked, a plant may die. Both mealybugs and scales produce large amounts of honeydew. The sweet excretion attracts ants, and patches of sooty mold grow where the honeydew drops beneath the infested plants. Mealybugs and scales can be killed with thiocyanate or nicotine-sulfate sprays, usually applied in white-oil emulsion. Parathion and malathion are also excellent controls but must be used with extraordinary caution. Rinse plants with a strong spray of water about an hour after application to prevent damage to the plant by chemical



LONG-TAILED MEALYBUGS have long filaments at the tip of the body. Females give birth to nymphs. The Mexican Mealybug lays eggs.

MEXICAN MEALYBUGS are common pests in greenhouses and in warm climates attack plants outdoors. Hollyhocks, geraniums, and chrysanthemums are frequent victims.

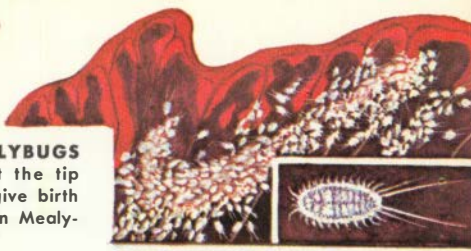
FERN SCALES are pests of bananas, orchids, citrus, and other plants outdoors in warm climates. In cool climates they occur indoors on ferns and other plants.

CACTUS SCALES are abundant, armored scales, found outdoors in southwestern U.S. or indoors on plants in greenhouses and homes.

HEMISPHERICAL SCALES are pests in warm climates or on indoor plants. Oval scales become strongly convex. Flat young scales are notched at rear.

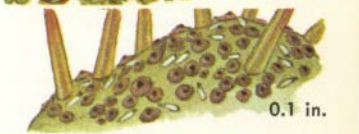
BROWN SOFT SCALES, flat and close to the color of their host, are pests in greenhouses; outdoors on gardenias and oleanders in warm climates.

GREENHOUSE ORTHEZIAS, related to scales and mealybugs, are pests in greenhouses and outdoors, attacking more than 100 species of plants.





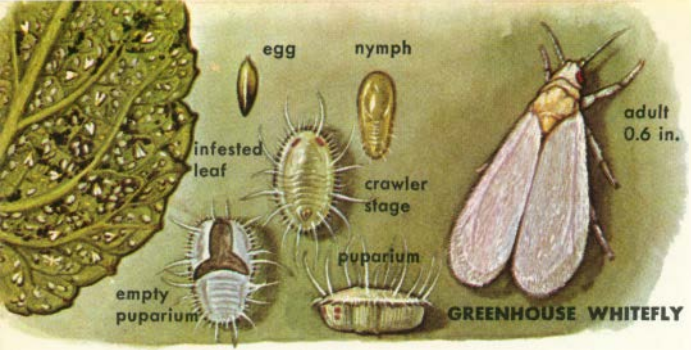






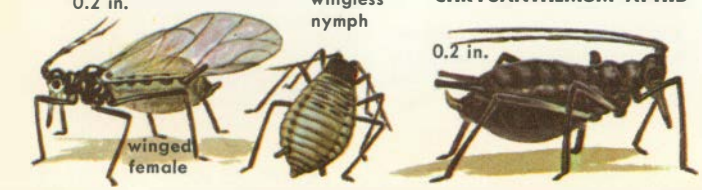


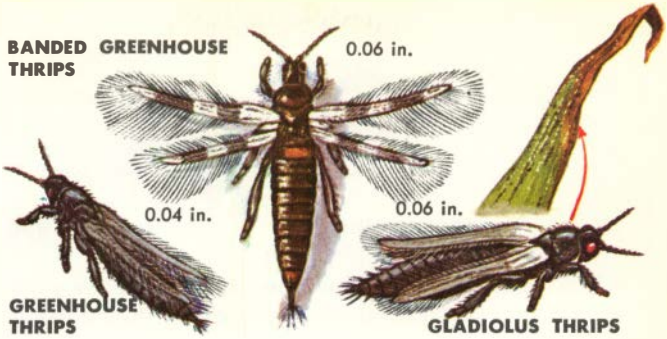




WHITEFLIES in large numbers may feed unnoticed on the underside of leaves until the white-winged adults are disturbed and take flight. Both the adults and nymphs suck sap from stems and leaves, causing an infested plant to wilt. In warm climates whiteflies are pests outdoors the year around; in cool climates they are principally pests in greenhouses or on plants kept in the home. Some species, such as the common Greenhouse Whitefly, spread outdoors during the warm months. Like aphids, whiteflies excrete honeydew. These pests can be killed with oil sprays and also with the organo-phosphate insecticides.

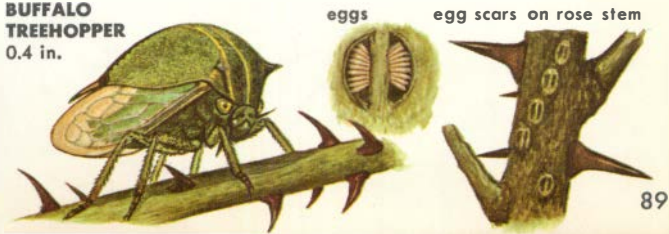
APHIDS are pests of flowers and shrubs. All aphids have similar life histories and habits. A few species feed on the roots of plants, but most kinds suck sap from leaves or stems. Control of aphids on ornamentals is the same as for vegetables (p. 66).

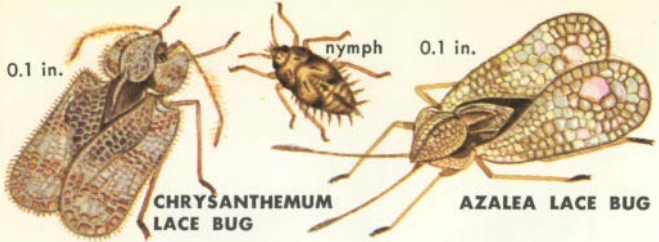




THRIPS, pests of a variety of plants, are much alike in appearance and life history (p. 72). Most thrips attack shrubs and flowers, particularly in warm climates, and they are especially damaging in greenhouses. The Greenhouse Thrips is found throughout the world. The Banded Greenhouse Thrips is a prevalent pest in western U.S., while the Gladiolus Thrips is distributed throughout the U.S. on gladioli, irises, and lilies. The leaves of infested plants turn white or silvery and then brown due to the loss of sap drawn out by the feeding thrips. Thrips can be killed with contact insecticides, and bulbs can be dusted with insecticide when stored.

TREEHOPPERS, related to leafhoppers (p. 68), lay eggs in crescent-shaped slits cut in twigs. Fungi develop in the slits, and the scarred twigs do not grow well. Nymphs of treehoppers suck the juices from grasses, lilies, and other plants. Spray with contact insecticide.



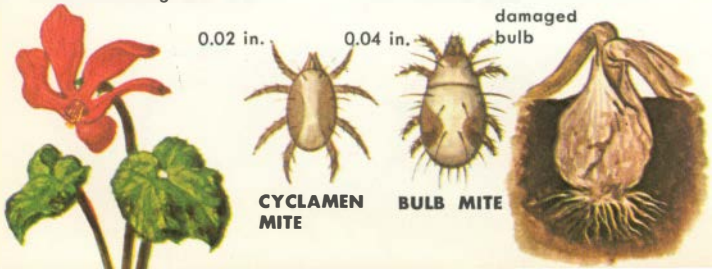


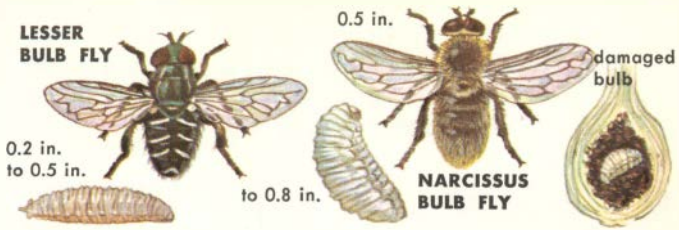
LACE BUGS, both the handsome adults and the spiny nymphs, suck juices from leaves or stems. They damage ornamentals and also vegetable plants (p. 73). Leaves of infested plants are spotted with dark, shiny excrement. Lace bugs overwinter as eggs attached to leaves and in warm weather produce two or more broods in a season. Contact insecticides should be used to kill adults or nymphs as soon as they appear.

MITES damage plants in greenhouses and attack a great many kinds of plants outdoors in warm weather. They are pests also of vegetables (p. 85), man (p. 45), and domestic animals (p. 54–55).

CYCLAMEN MITES attack cyclamens, delphiniums, marigolds, other garden flowers, and also strawberries. They feed on tender leaves in the plant's crown and also overwinter there. Foliage turns black. Immerse suspected seedlings in water at 110 degrees F. for about 20 minutes before setting them out.

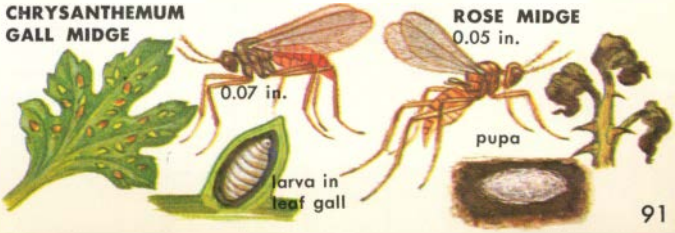
BULB MITES attack roots, corms, and bulbs of such plants as lilies, crocuses, hyacinths, gladioli, and tulips. Infested bulbs turn soft, and the stem of the plant breaks over. Destroy infested bulbs by burning or burying them deeply. Or immerse bulbs in water at 110 to 115 degrees F. for an hour and a half.





BULB FLIES attack bulbs of lilies, narcissuses, irises, hyacinths, and such root crops as onions, carrots, and potatoes. The maggots feed inside the bulbs, opening them to fungi. They pupate in the bulb or in the soil. The Lesser Bulb Fly produces two broods a year, the Narcissus Bulb Fly one. Maggots of the Lesser Bulb Fly usually infest already weakened or injured bulbs, and many maggots may occur in one bulb. Only one maggot of the Narcissus Bulb Fly is ordinarily found in a bulb. In early spring, when the adult flies lay their eggs, cover plants with cheesecloth. At harvest, destroy bulbs that feel soft and are probably infested. Treat the others in hot water, as for Bulb Mites (p. 90).

MIDGES are small flies. Some species, such as larvae of the Chrysanthemum Gall Midge, form galls on stems or leaves. Maggots of the Rose Midge feed on buds and new shoots, deforming and causing them to die. Full-grown maggots burrow into the soil to pupate. Remove and destroy infested parts of plants. Treat soil with a contact insecticide; spray plant to kill larvae.



LEAF MINERS, the larvae of certain moths, flies, beetles, or sawflies, feed between the epidermal layers of a leaf, causing blisters, blotches, or tunnels. In time the leaves turn brown and drop off.



AZALEA LEAF MINERS, the caterpillars of a small moth, feed in the leaf tissues until about half grown, then emerge and feed at the tip or margin. The caterpillar rolls or folds the leaf over itself and feeds inside this cover, in which it also pupates. Leaf rolls can be pulled off and destroyed. Dust plants with a stomach-poison insecticide to kill larvae feeding on surface.

ARBORVITAE LEAF MINERS eat out the inside of needles at the branch tips. The caterpillars overwinter in the branches and emerge in late spring or early summer. Females lay eggs on the foliage. Cut and destroy infested tips. Adults and newly hatched larvae should be killed with a contact insecticide.

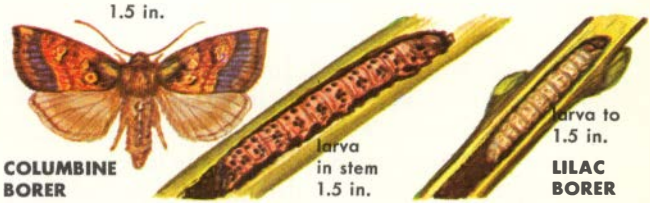
COLUMBINE LEAF MINERS, also pests on asters, are fly larvae. As many as a dozen larvae attack one leaf. Infested leaves should be burned or buried. Spray plants with a contact insecticide.

LARKSPUR LEAF MINERS mine in leaf tissues of delphiniums. Adult flies puncture the undersurface of leaves, turning them brown. Destroy infested leaves. Spray or dust plants with a contact insecticide. Cultivate soil to kill pupae.

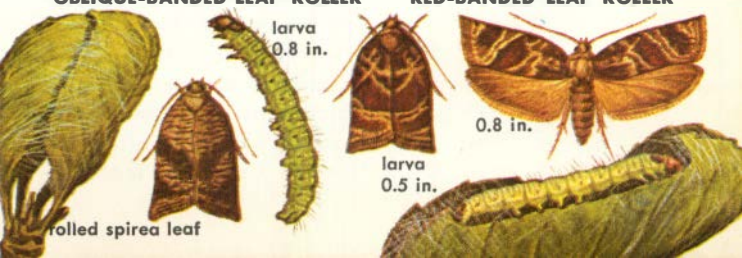
BORERS feed inside stems, leaves, fruit, or roots. They are difficult to reach with sprays or dusts. An infected plant wilts and in time dies or breaks off. Bacteria and fungi enter the plants through the holes made by borers.

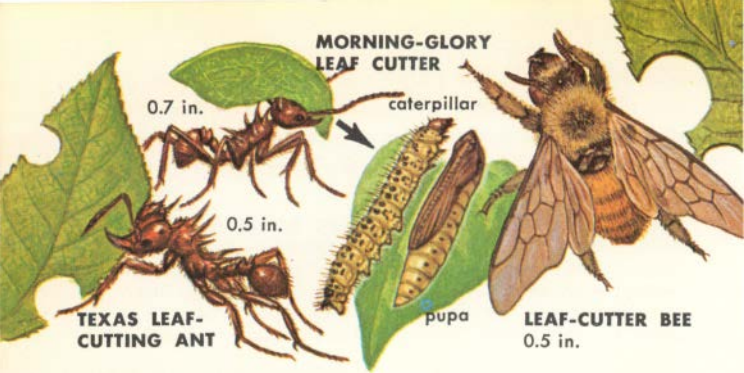
COLUMBINE BORERS lay eggs on the ground or in debris near plants. A fall cleanup of debris destroys many eggs. Contact insecticides in soil at base of plants kill caterpillars.

LILAC BORER caterpillars winter inside the stem. Cut off and burn infested stems. Or kill borers inside holes in stems with a wire probe or squirt in a few drops of carbon bisulfide.



LEAF ROLLERS twist or roll a portion of a leaf over themselves and fasten it together with silk. They feed on the surface or at the edge of the leaf, and when full grown, pupate inside the roll. The two most common species of leaf rollers, attacking a wide variety of flowers and shrubs, are the Oblique-banded and the Red-banded. Both stomach-poison and contact insecticides are effective controls and should be applied as soon as damage is discovered.





LEAF CUTTERS are bees, caterpillars, ants, or other insects that cut large pieces from leaves. Leaf-cutter ants, found in Louisiana, Texas, and southward, take the pieces of leaves to their nest and chew them up to make a mulch on which fungus grows. Leaf-cutting bees roll the piece of leaf into a thimble shape to line the stem cavity in which the larva is feeding. The Morning Glory Leaf Cutter cuts off the leaves of morning glories, zinnias, dahlias, and other flowers. The caterpillars feed at night and hide during the day in the wilted leaves. Use stomach poisons as dusts or sprays.



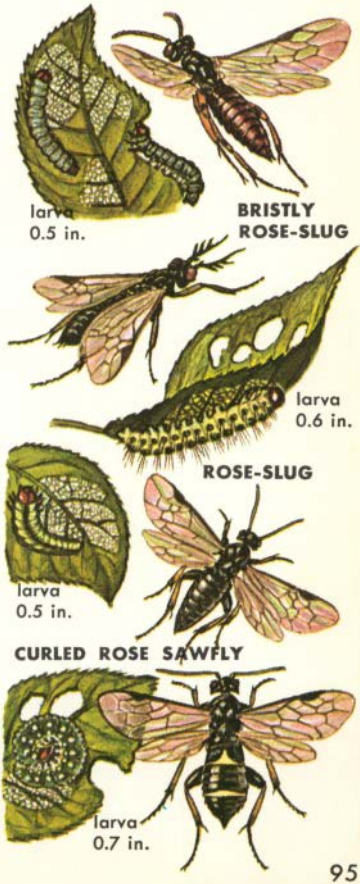
BAGWORMS move about in a bag of tough silk, covered with needles or twigs. Especially damaging to conifers. In late summer the caterpillars form pupae inside the bags. Winged males emerge in the fall and mate with the wingless females, which lay their eggs inside the bag and never emerge. Bags can be picked by hand, or plants sprayed with a stomach-poison insecticide while larvae are feeding.

SAWFLIES belong to the same order of insects as bees and wasps. Instead of stingers, the females have a saw-tooth-edged ovipositor with which they cut slits in leaves or bore holes into stems to lay eggs. The larvae of sawflies resemble caterpillars of moths and butterflies and, like them, feed on foliage.

VIOLET SAWFLIES, pests of both violets and pansies, feed at night. They first eat out the underside of the leaf and skeletonize it. Then they eat holes through the leaf and may completely defoliate a plant. Blisters are formed on the leaves where the females lay eggs. Spray plants with a stomach-poison insecticide.

ROSE-SLUGS are the larvae of several species of sawflies. Bristly Rose-slug larvae feed first on the undersurface of the leaves, skeletonizing them, then eat holes through the leaves. As many as six broods are produced in a season. The Rose-Slug feeds on the upper surface of the leaf and produces one generation in a season. Larvae of the Curled Rose Sawfly eat the whole leaf, usually feeding in a curled position like a grub. Slugs can be killed with stomach-poison insecticides applied to leaves in early stages of the feeding.

The Bristly Rose-slug and the Rose-Slug pupate in debris or loose soil; hence a fall cleanup destroys the pupae. The Curled Rose Sawfly larvae pupate in woody or pithy stems. Paint pruned ends of stems and get rid of debris.



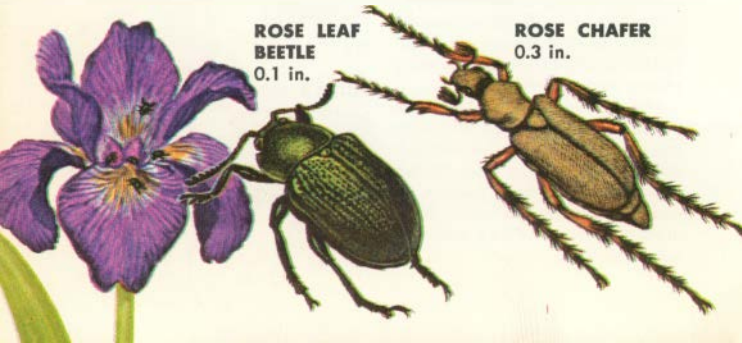


BLACK BLISTER BEETLES are pests of asters, zinnias, chrysanthemums, anemones, and other flowers. They commonly eat the petals in preference to the leaves. The Black Blister Beetle resembles the Striped Blister Beetle (p. 74) in life history and habits and is controlled by the same methods.

BEETLES Some of the many species of beetles feed on the foliage, flowers, stems, roots, or fruit of shrubs and flowers. Some are damaging only in the larva, or grub, stage; others do their greatest damage as adults. Both larvae and adults have chewing mouthparts. Some are pests in both stages. Many beetles are general feeders; others attack only one kind or related plants.

ROSE LEAF BEETLES feed on the blossoms of irises and peonies as well as roses. They also eat leaves, blossoms, buds, and young fruit of pears, plums, apples, peaches, strawberries, and others. They can be hand-picked or jarred into a pail of kerosene and water. They feed deep in flowers or buds and are hard to reach with insecticides. Pyrethrum or other contact insecticides are effective.

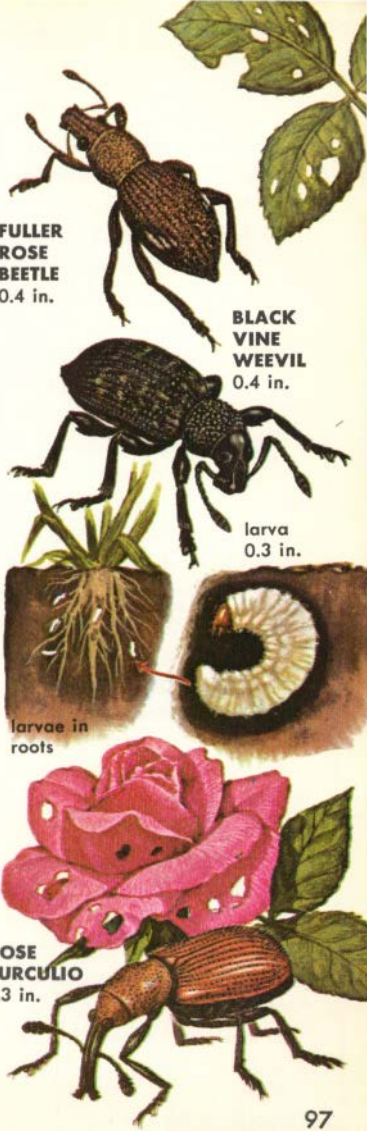
ROSE CHAFERS are general pests of flowers and shrubs and also of many fruit and vegetable crops. Adult beetles appear in late spring or early summer, feeding first on the flowers and then on foliage. The larvae feed on the roots of grass and burrow deep into the soil to hibernate. Adults can be hand-picked, or infested plants can be sprayed. Rose Chafers are deadly poisonous to chickens.



FULLER ROSE BEETLES are weevil pests (p. 78) of roses, carnations, geraniums, gardenias, chrysanthemums, azaleas, and many other shrubs and flowers. Adults feed at night, eating the margins of the leaves. The grubs feed on the roots, causing the foliage to turn yellow. They can be controlled by the same methods used for the Rose Curculio.

BLACK VINE WEEVILS are pests of gardenias, azaleas, begonias, spirea, arborvitae, rhododendron, and many other flowers and shrubs. The larvae feed first on the root hairs of plants and then on larger roots, stripping them of bark. The grubs hibernate in winter, feed again on the roots in spring, then form pupae and emerge as adults in early summer. The adult weevils (p. 78) are active at night, eating foliage for about a month before laying eggs in soil. Spray or dust with a stomach-poison or a contact insecticide.

ROSE CURCULIOS are weevils (p. 78) with especially long snouts, or beaks. They eat holes in the stems or unopened buds of roses. Injured buds may not open, or if they do, the petals are filled with holes. The larvae develop in the young fruit or hips, and when full grown, drop to the ground to pupate. Beetles can be hand-picked or jarred from the plant into a container of water and kerosene. Dust plants with a stomach-poison or contact insecticide. Destroy infested rose hips.

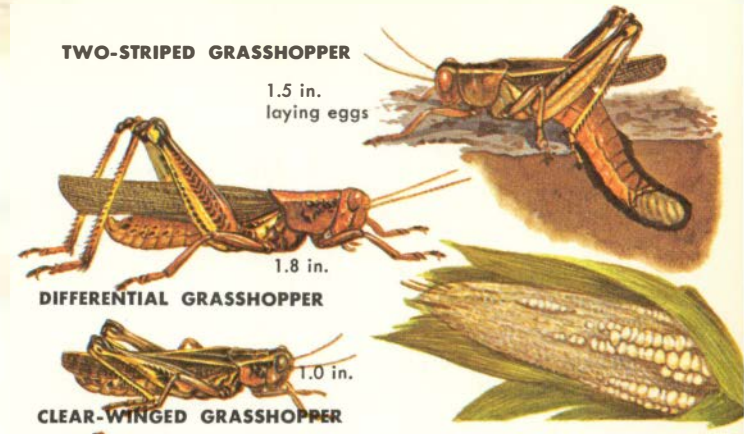


FIELD AND FORAGE CROP PESTS

All field crops are food for insects. Losses average 10 percent, but in epidemic outbreaks entire crops are lost.

GRASSHOPPERS About 600 species of grasshoppers inhabit North America. Ninety percent of the damage is due to five species that attack field crops; more than 20 species are damaging to grasslands. The dry grasslands east of the Rocky Mountains, where the annual rainfall is less than 30 inches, periodically have grasshopper outbreaks in which the crop losses amount to millions of dollars. Most species of grasshoppers are general feeders, though they prefer young, green plants. In epidemic outbreaks the hungry hordes will eat any food available. They will strip a tree or bush of its foliage and then feed on the bark. In heavy outbreaks, with 50 or more grasshoppers to the square yard, grass is cropped close and permanently injured, exposing the land to wind and water erosion.

Most grasshoppers lay eggs in late summer or early fall. The female pushes her ovipositor as deep as two inches into the soil, depositing her eggs in packets consisting of as many as 100 eggs. These masses of eggs, glued together with particles of soil, are called pods. Each female may lay as many as a dozen pods. The eggs hatch in the spring, and the nymphs begin eating immediately. The number of times they shed before becoming adults varies with the species but is usually five or six. Most species produce only one generation a year, but the Migratory Grasshopper and several others may produce two generations in warm climates. Plowing or disking the land in the fall buries some of the eggs so that the nymphs cannot make their way to the surface.



These five species of grasshoppers are the most damaging to field and forage crops in the United States. The ear of corn above has only a few scattered kernels because grasshoppers ate off silks before pollination.



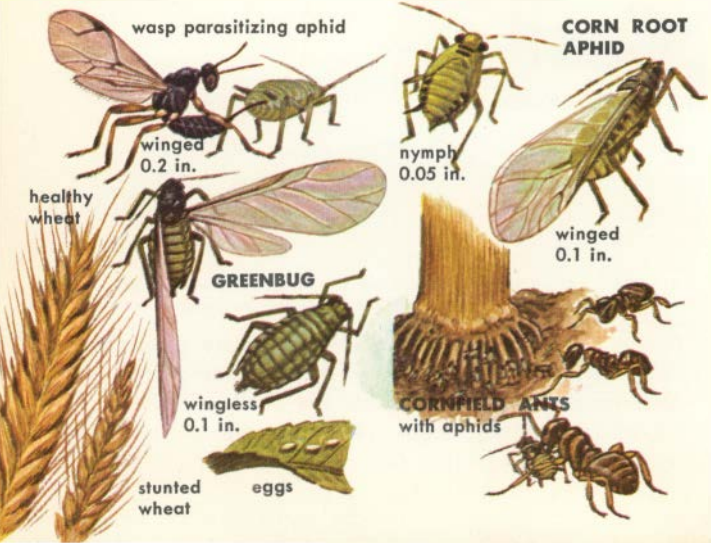
Bare range land was scoured by foraging grasshopper horde. Grass still grows heavy under screened plot.

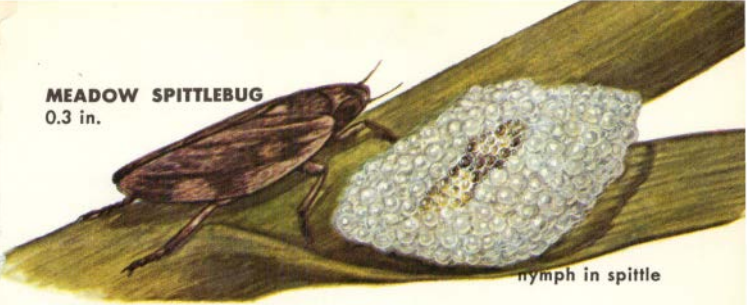
Others are exposed to the weather or to predators. Poisoned baits (sweetened bran containing arsenic, chlordane, or similar poisons) are used effectively to kill adults, and large areas in western states are sprayed with contact insecticides from airplanes.

APHIDS damage plants by sucking the sap from the stems, leaves, or roots. They stunt the plant's growth, or in heavy infestations cause it to die. Aphids have complex life cycles (p. 66).

GREENBUGS are aphid pests of grains. In warm climates they are active throughout the year. In cool climates males and females are produced in late summer. They mate, and the females deposit eggs in the folds of leaves. Greenbugs are parasitized by a small wasp that lays its eggs in the aphid's body. The wasp's larvae feed on the aphid's internal organs. In a cool spring, the aphids build up a large population before the wasps become active. Plow under volunteer crops. Plant resistant varieties. Use contact insecticides to check infestations of Greenbugs.

CORN ROOT APHIDS infest the roots of corn. The corn grows well until about a foot tall and then becomes stunted and yellowed. The aphids winter in the egg stage, stored in the nests of the Cornfield Ant. As soon as they hatch in spring, the young are pastured first on the roots of weeds or grasses, then on corn plants. The aphids produce winged generations that fly to other plants, where they are captured by ants and put to work. The ants eat the honeydew expelled by the aphids. Ant nests should be destroyed by plowing or by treating the soil with a contact insecticide.

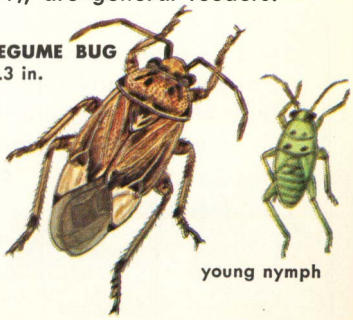


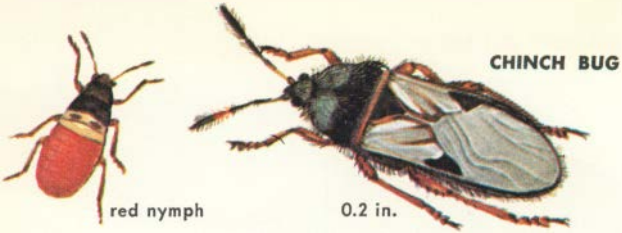


SPITTLEBUGS damage plants as nymphs, sucking the juices from stems or leaves. The nymphs surround themselves with a mass of froth, or spittle, as they feed. The squat, broad adults are sometimes called froghoppers. The Meadow Spittlebug, a pest of alfalfa and other legumes and also of many ornamentals, produces only one generation in a season. The nymphs hatch from eggs laid in stubble. Spray plants with contact insecticides before fall harvest to kill egg-laying adults or in early spring to kill young nymphs.

PLANT BUGS, also called leaf bugs, are a family of true bugs containing many species that damage and deform plants by sucking out juices. Some feed on only one group of plants, such as grasses; others, such as the Tarnished Plant Bug (p. 71), are general feeders.

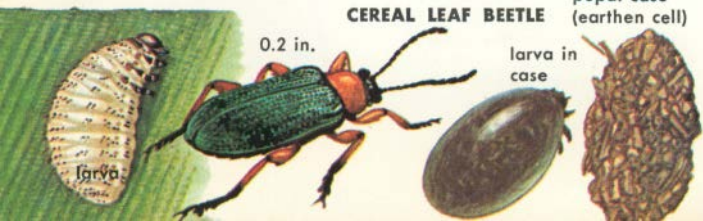
LEGUME BUGS are pests of legumes and other plants. Nymphs are most damaging, but adults also feed on plants. Both introduce a toxin causing deformities. Adults overwinter, and females lay their eggs in plant tissues in spring, with four or five generations produced in a season. Use a contact insecticide in spring when nymphs begin to feed. Do not spray plants in flower, thus killing bees that pollinate crop.





CHINCH BUGS are major pests of corn but also damage other grains and grasses. Adults overwinter in debris, and in the spring the females lay eggs at the base of plants, on which the nymphs feed by sucking out juices. Young plants are commonly killed; older plants survive but may not produce. As food plants are exhausted in one place, the nymphs migrate in droves to find new food plants. Chinch Bugs can be killed with contact insecticides sprayed or dusted on infested plants, or the insecticides may be used as a chemical barrier to prevent entry of crawling nymphs. Some crop varieties are resistant to Chinch Bugs. Crop rotation prevents population buildup.

CEREAL LEAF BEETLES, from Europe, were first found in the U.S. in 1962 and are now a potential major pest of grain crops in the Midwest. Adults survive cold winters by hibernating under debris. The larvae hatch from eggs laid in early spring and feed on the leaves of young plants. They pupate in June, and adults appear in July, feeding until winter.

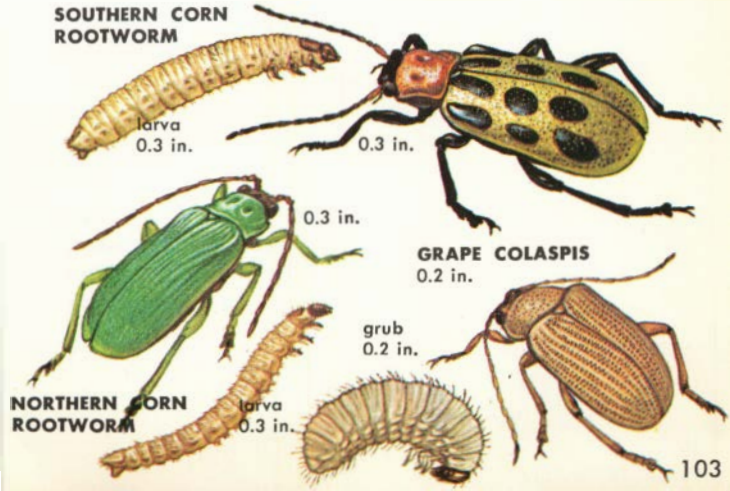


ROOTWORMS are grubs, or beetle larvae, that injure plants by feeding on or in their roots. Often the adults damage entirely different plants.

NORTHERN CORN ROOTWORMS, which feed only on corn, are pests from New York westward to the Rocky Mountains, especially in the northern Mississippi Valley. Infested plants grow slowly and are weakened so that they topple in wind or heavy rain. The larvae also transmit wilt, a bacterial disease. In midsummer the larvae leave the roots and pupate in the soil. The adults, which feed on a variety of plants, die after laying eggs around roots of cornstalks in the fall. Eggs hatch the following spring. Rotating crops is effective. Chemical controls include soil treatment with contact insecticide before plowing, or sprays or dusts on adults.

SOUTHERN CORN ROOTWORM damage is similar to injury by the Northern Corn Rootworm, but worms also bore into stalks at soil line. Adults are equally damaging.

GRAPE COLASPIS grubs (Clover Rootworms) feed on the stems and foliage of grapes and other plants. Adult beetles emerge in midsummer and lay their eggs around roots of cover crops such as clover. The grubs feed on the roots until cold weather, then hibernate until spring, when they continue feeding. If a field is plowed in spring and then planted in corn, the half-grown grubs feed on roots. Fall plowing exposes grubs to freezing.

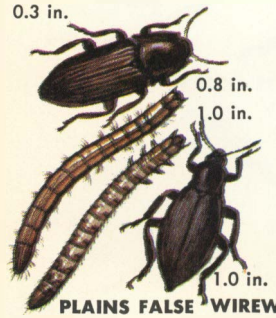




FLEA BEETLES, especially abundant in cool, wet seasons, attack many field and garden crops. In addition to eating leaves and generally weakening a plant, they transmit the bacteria for Stewart's disease, a wilt. Heavy infestations sometimes cause a complete loss of crops. Keep fields free of weeds under which the beetles hibernate in winter. For other controls see p. 62.



WHITE GRUBS of a number of species eat the roots of lawn grasses, corn, wheat, and forage crops. Infested corn plants may die after growing to a height of about two feet. In addition to the grubs of May and June beetles, larvae of the Oriental Beetle are serious pests. Control by soil fumigation and by other methods described on p. 65.

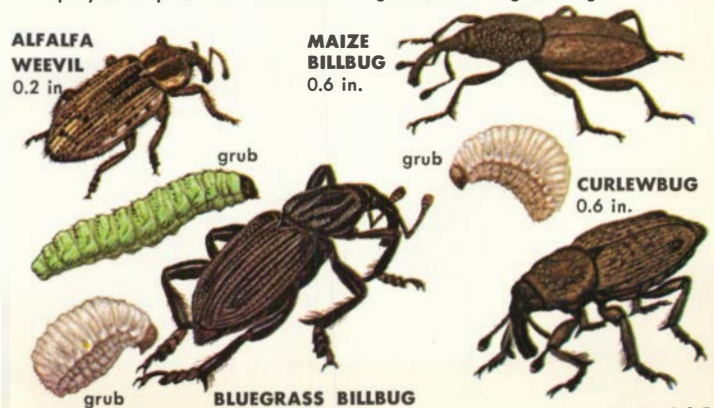


WIREWORMS of several species injure corn, wheat, lawn grasses, and root crops. The Plains False Wireworm, particularly damaging to wheat, is a darkling beetle larva rather than a click beetle as are true wireworms. Controls are given on p. 63.

WEEVILS, the largest family of beetles, are easily recognized by their long snout, at the end of which are their chewing mouthparts. When disturbed, many weevils "play dead." Some weevils are pests of vegetable crops (p. 78), fruits (p. 125), and stored products (p. 146). Many are as damaging in the grub, or larva, stage as they are as adults.

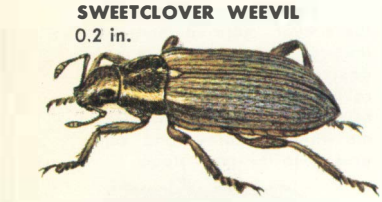
ALFALFA WEEVILS, important pests in western U.S., winter as adults in debris on the ground. In spring they emerge and feed on alfalfa or other legumes. The females lay their eggs in cavities chewed into the stems. At first the grubs feed where they hatch; later they move up to the tips. Often the plant is stunted, and the entire first-growth crop may be lost. When full grown, the larvae spin cocoons, and the adults appear in about ten days. Adults can be killed with contact insecticide. Consult agricultural agent for best time to apply and for advice on use of sprayed crop as livestock feed.

BILLBUG is a name used for several species of snout beetles that attack corn, wheat, and other grains. Adult Maize Billbugs eat holes in the stems and leaves of corn. The grubs, even more damaging, feed on the taproots and in the pith of the stalks, forming pupae in late summer or early fall. Adults hibernate in winter. Crop rotation is an effective control for the Maize Billbug and the similar, more southern Curlewbug. Maize Billbugs can be destroyed in hibernation by raking a field and burying debris. The Bluegrass Billbug feeds on wheat, timothy, and other grasses in the grub stage.





CLOVER LEAF WEEVILS, also pests of alfalfa, are most damaging in early spring and may destroy an entire crop. The grubs feed on leaves at night and hide beneath plant during the day. They complete growth by late spring and spin a cocoon in the soil or on the plant. Adults emerge in early summer. After a brief period of feeding they become relatively inactive until fall, then mate and the females lay eggs. Larvae that hatch in the fall hibernate until spring. Some eggs do not hatch until spring. In wet seasons many larvae are killed by fungus disease. A field can be plowed and planted in grass, or crop sprayed with a contact insecticide.

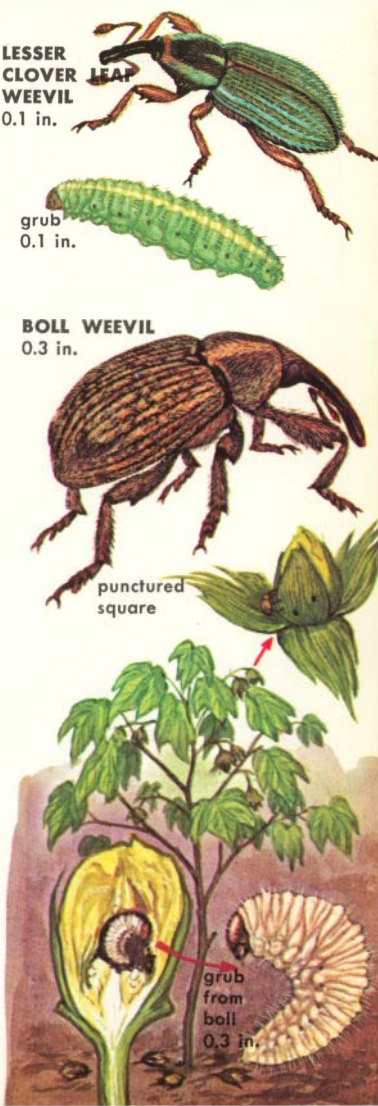


SWEETCLOVER WEEVILS and closely related Clover Root Curculios are pests of nearly all legumes. The grubs burrow into the roots, causing plants to wilt and die. These weevils usually overwinter as young larvae, though in some regions they pass the winter in the egg or adult stage. Larvae complete their development by late spring, then form pupae and emerge as adults by summer. Adults feed on foliage for about a month, after which they become less active until fall, when they begin to feed again. At this time they mate and females lay eggs on food plant. Control is difficult. Fields can be plowed in early spring or late fall and planted in grass or other non-legume plant. Contact insecticides will kill weevils but may make crop unusable as a livestock food.



LESSER CLOVER LEAF WEEVILS are most damaging to red clover but may also attack alfalfa and sweetclovers. The damage, greatest in dry seasons, is done largely by the grubs, which feed on the stems, leaves, and buds. An infested plant wilts and dies. No good control methods have been discovered.

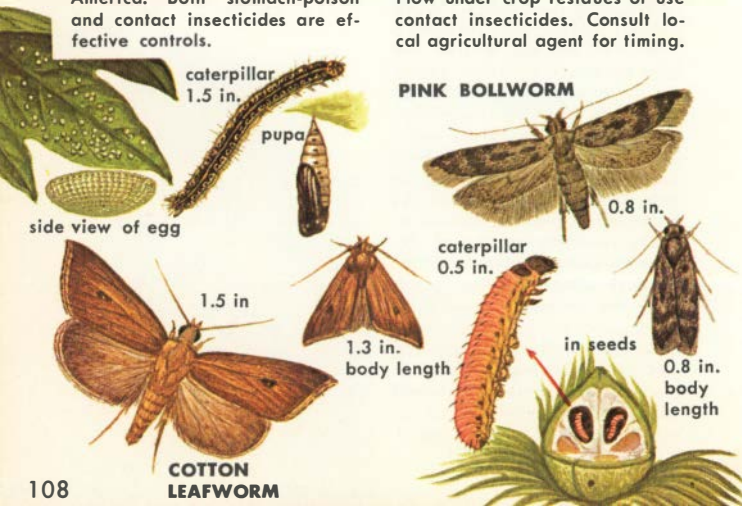
BOLL WEEVILS are one of the more than 100 insect pests of cotton. As many as seven generations of Boll Weevils are produced in a season, damaging the plant at all stages of its growth. Each generation completes its development in about three weeks in good weather. Adults that emerge from hibernation in debris near cotton fields begin feeding on the buds of young cotton plants. The females lay one egg in a deep puncture in each developing flower bud, or square. If not enough squares are available, more than one egg may be laid in a square. The larvae feed in the square, causing it to turn yellow and drop. In heavy infestations the bloom of an entire crop is destroyed. When bolls do form, the weevils feed inside. Young bolls drop from the plant; older ones are stained or decay. Controls consist of destroying cotton stalks or debris in which adults hibernate, planting early maturing varieties of cotton, and using contact insecticides to kill the feeding larvae and adults. Timing is critical in the success of these controls and varies with local conditions. Consult regional agricultural agent.

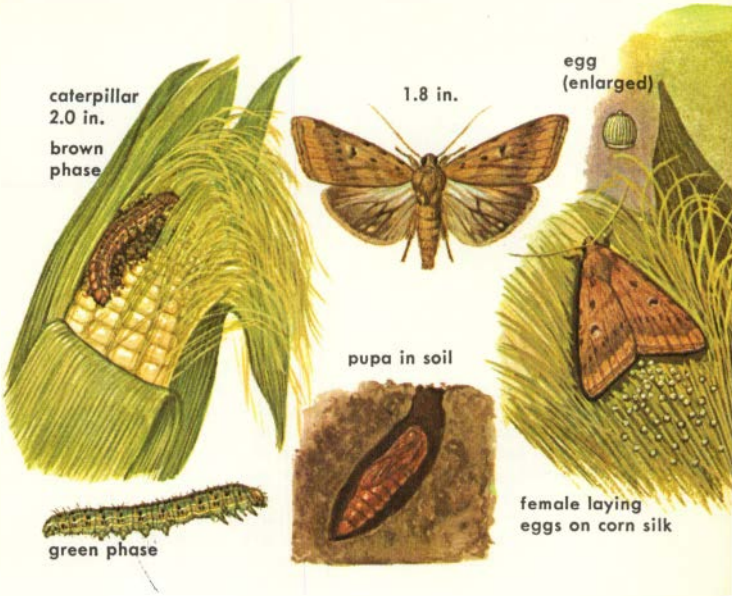


CATERPILLARS of moths and butterflies are common pests of field and forage crops. Methods of combating them are much the same as those used in controlling caterpillars that damage vegetable crops (p. 80). All have strong chewing mouthparts.

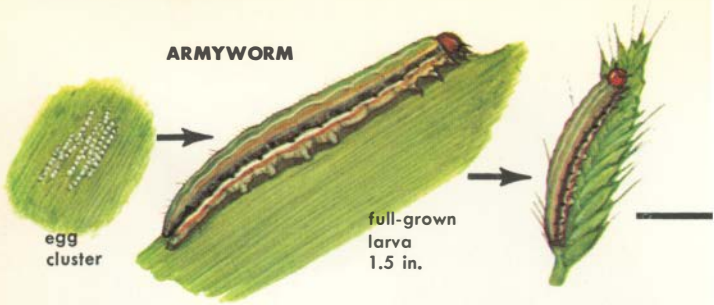
COTTON LEAFWORMS crawl by looping their body, like measuring worms. Unlike almost all other moths, the adults may be pests, using their spiny mouthparts to make slits in grapes, peaches, or other fruit to get the sweet juices. The larvae hatch from eggs laid on the underside of cotton leaves. Later they pupate in folded leaves. A life cycle is completed in about a month, with as many as three or four generations a season. No stage survives winter in the U.S., the pest invading each year from Central America. Both stomach-poison and contact insecticides are effective controls.

PINK BOLLWORMS feed on cotton blossoms, or squares, causing them to wilt and drop. Later they feed in the bolls. Pink Bollworms winter in cocoons in the soil, inside bolls, or in the seed. Larvae may remain in this resting stage for more than two years, which accounts for the world-wide spread of this pest. Each generation requires about a month, with as many as six generations a season. Worms in the seed are killed by heat (145 degrees F.) or by fumigation. Early crops give harvests before the pests are numerous. Plow under crop residues or use contact insecticides. Consult local agricultural agent for timing.





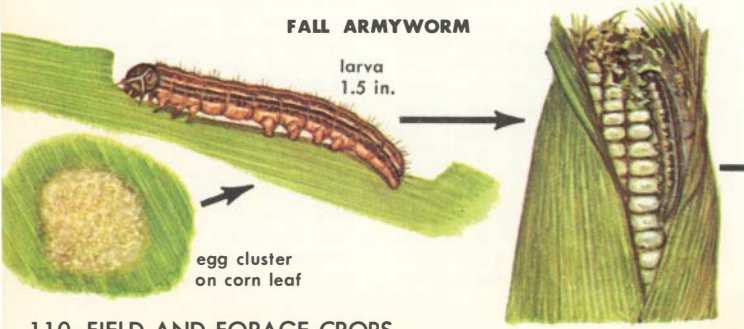
CORN EARWORMS, known as Bollworms and Tomato Fruitworms, are the major pests of sweet corn in the U.S. From 500 to more than 2,000 eggs are laid by each female. The larvae feed on the unfolding leaves, sometimes stunting the plants. Greatest damage occurs when the corn is in the tassel, or silk, stage, as the larvae that hatch on the silks feed there and also on the developing kernels. In addition to destroying the kernels, the larvae open avenues for molds and for other insect pests. The worms feed also on the flowers of tomatoes and eat the green fruit. They feed on the buds of tobacco plants and in the seed pods. In cotton-growing areas they feed on the tips of the plants, on the blossom, and in the bolls. Up to seven generations are produced each year in warm climates; three or four in the Corn Belt, only one in northern states. Corn Earworms overwinter in the soil in a pupa case, hence plowing in late fall destroys many or exposes them to freezing temperatures. Feeding worms can be killed with contact-insecticide dusts. Some hybrid corn varieties are resistant to Corn Earworms. Early maturing varieties can be harvested before the pest population builds up.

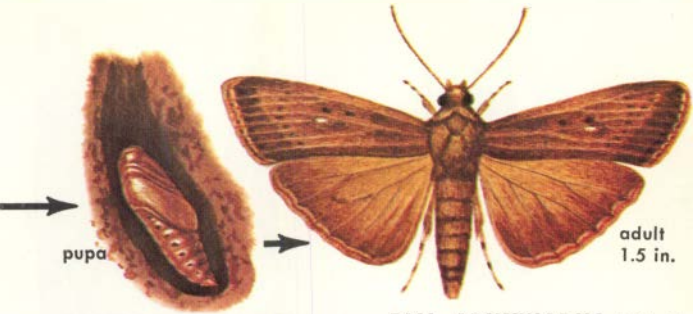


ARMYWORMS hibernate as half-grown caterpillars that begin feeding in spring and are full grown by early summer. They burrow into the soil, pupate, and emerge as night-flying moths that are identified by the white dot on each front wing.

Female moths, after a period of feeding on nectar or decaying fruit, lay their eggs on grass or other plants. Larvae hatch in about a week and begin feeding ravenously on the plants around them. If conditions have been favorable, many thousands of caterpillars are produced. When the plants are consumed in one area, the hungry hordes move in "armies" to find a new supply. Caterpillars of this second, or summer, generation become full grown in late summer. They pupate, and the adults emerge in the fall, each female laying as many as 2,000 eggs, in clusters of 25 to 100. These hatch into the larvae that overwinter.

The summer generation does the greatest damage, and in the years of severe outbreaks many crops are attacked and completely destroyed. The caterpillars hide during the day and feed at night; hence a crop may be destroyed completely before the caterpillars are noticed. Armyworms are parasitized by a fly that lays its eggs on the caterpillar's back; the fly's larvae

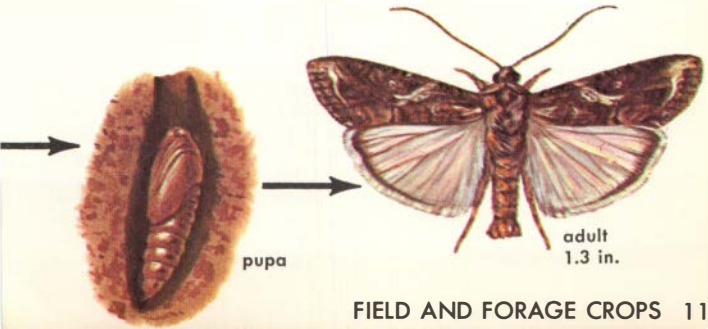


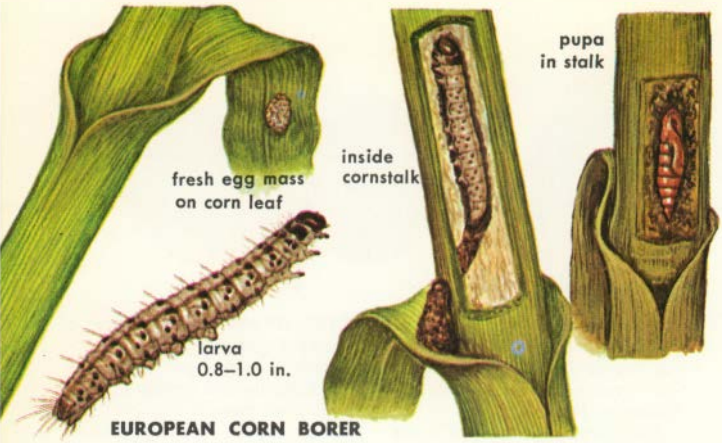


then feed on the caterpillar and kill it. A tiny wasp that lays its eggs inside the Armyworm's eggs is an even more effective natural control of this pest.

Advancing "armies" of these caterpillars can be trapped in deep furrows containing kerosene or a contact insecticide. Poison-bran baits such as those used for grasshoppers (p. 98) can be spread in the path of the migrating caterpillars, or fields can be sprayed with contact insecticides. When the worms disappear, indicating that they have burrowed into the ground to pupate, shallow plowing will expose the pupae to predators and to weather.

FALL ARMYWORMS are a southern species closely related to the Armyworms. Sometimes the moths fly into northern states, appearing there in the fall. They do not survive northern winters, however. In the South as many as six generations are produced in one season. The caterpillars feed first on grass, then move to corn or other field and vegetable crops. In the South the caterpillars go by the name of Grass Worms. Fall Armyworms do not hide during the day as do Armyworms. In addition to the controls effective against the Armyworm, it is important to keep fields free of grass on which the larvae feed first.





EUROPEAN CORN BORER

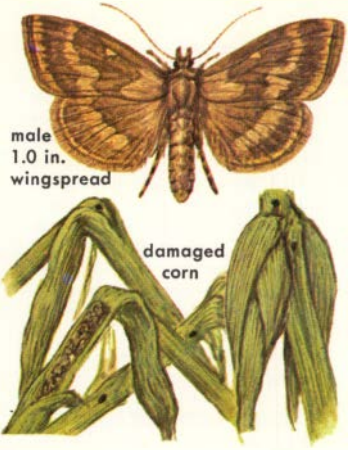
EUROPEAN CORN BORERS are the most injurious pests of corn in the U.S. From their point of introduction in the Boston area, just before 1917, they have spread across the continent to the Rocky Mountains.

Originally the European Corn Borer produced only one generation each season, but in the East it now usually produces two. Though corn is preferred, the caterpillars, particularly those of the second generation, will feed on many other kinds of plants. European Corn Borers overwinter as caterpillars in the stems of food plants. In the spring they pupate in the stem, emerging as night-flying adult moths in about 10 days. During the day the moths stay in hiding under the corn leaves or in weeds nearby. The female moth lays her eggs in flat clusters of a dozen or more on the underside of the leaves of food plants. Each female may lay a total of nearly 2,000 eggs, which are at first white but later turn yellowish.

Newly hatched larvae are yellowish. They feed first on the leaves, then bore into the stem or the ear, where they feed until full grown, in about a month. Where there are two generations per year, the first is completed by midsummer, and the larvae of the second generation are full grown by winter.

Often many borers attack a single plant, weakening it and causing it to fall over. Food canals in the cornstalk are cut off so that ears of corn do not form properly. Borings are also openings for other insect pests and for rot fungi.

Stems and stalks in which borers might hibernate should be plowed under in the fall or early spring. Resistant varieties of



corn should be planted. Some hybrid varieties give a good yield of corn even though infested with borers. Late planting of any variety will reduce the infestations but may also lower the yield of corn. Where economical to do so, corn may be rotated with legumes. Of the many natural enemies that biologists have introduced from Europe, the most effective are three species of wasps and a species of fly, all of which parasitize the caterpillars. Contact insecticides can be applied to infested plants either as dusts or sprays, but their effectiveness depends to a great degree on proper timing. Generally the insecticide is applied when 70–80 percent of the plants in a field show signs of infestation. Local agricultural agents can advise the time and recommended rates of spray per acre for use in a particular area.

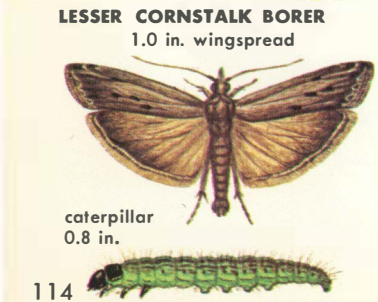
TOBACCO HORNWORMS are the large caterpillars of attractive moths. They overwinter as a distinctive chrysalis, with its tongue in a separate handlelike projection. The handle is longer than the closely related Tomato Hornworm's (p. 82). The giant caterpillars are ravenous feeders on the leaves of many plants. They can be destroyed by hand-picking them, or if especially abundant, with insecticides. Fall plowing to expose the pupae is also effective. At rest, caterpillars hold front of body erect in a stiff sphinxlike pose. The naked pupa has a distinctive handle in which the proboscis fits. Swift-flying adults are called sphinx or hawkmoths.





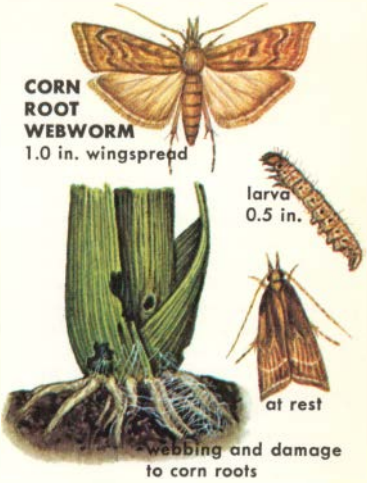
STALK BORERS are moths that overwinter as eggs attached to grass or weeds. The eggs hatch in early spring, and the larvae bore immediately into the stem of a plant, usually the one on which the eggs were laid. Later the caterpillars move to giant ragweeds, corn, and other large plants. In August they pupate, either in the stem or in the soil nearby, and emerge as adult moths in late summer or early autumn. The females lay eggs before winter. Stalks and debris should be plowed under in fall.

SOUTHERN CORNSTALK BORERS are pests from southern U.S. to South America. The similar Southwestern Cornstalk Borer occurs only in southwestern United States and Mexico. Infested corn is stunted, the stalks enlarged or swollen. Ears are poorly formed and may drop. The caterpillars overwinter in the cornstalks, change to pupae in early spring, and emerge as adults before summer. As many as three generations are produced in a season. Destroy stalks harboring hibernating larvae; rotate corn with legumes.

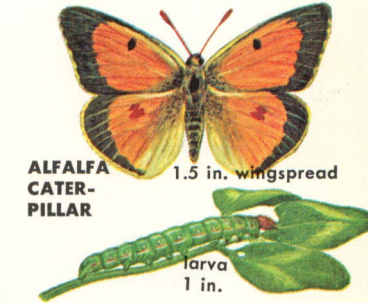


LESSER CORNSTALK BORERS, pests in southern U.S., bore into the base of cornstalks and also legumes, stunting and deforming the plants. They usually overwinter as larvae, forming pupae in late winter and emerging as adults in early spring. Two generations are produced in a season. Destroy stalks in which larvae overwinter.

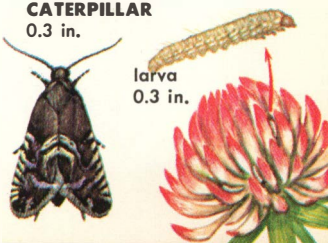
WEBWORMS are general feeders, though some species are especially damaging to lawns or to particular field crops. Bluegrass Webworms and related species are lawn pests. They feed only at night, cutting off blades of grass and dragging them into their silk-lined tunnels formed along the surface of the ground. The adult moths, which have a prominent snout, are commonly seen flying over grassy areas at dusk. The Corn Root Webworm (illustrated) attacks corn, tobacco, and other crops as well as grasses in which they hibernate. Plowing is an effective control for pests of field crops. Lawns can be treated with a contact insecticide.



ALFALFA CATERPILLARS feed on alfalfa and other legumes. Winter is passed in the pupa stage, from which butterflies emerge in early spring. Females lay eggs on the leaves of plants, on which the larvae feed. There may be seven generations a year. Plants can be sprayed with a contact insecticide if the crop is not used for hay.



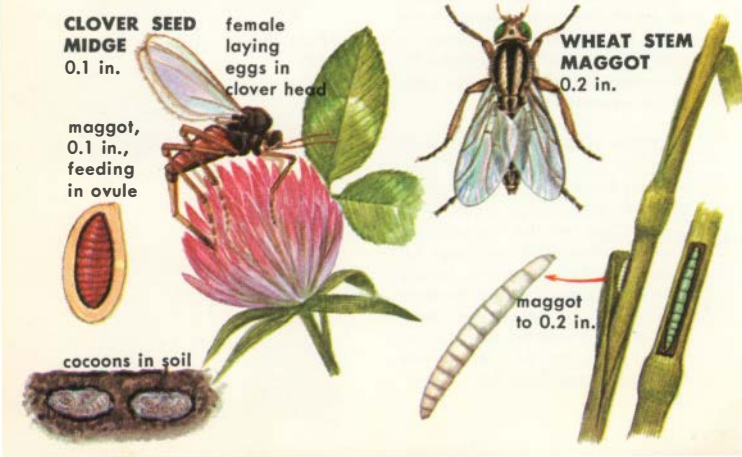
CLOVER HEAD CATERPILLARS feed in the clover head, preventing flowers from opening, or on green developing seeds. First-generation moths appear in early summer and lay eggs on clover plants, where the larvae feed and pupate. Three generations may be produced each season. Early cutting of crop destroys many larvae. The larvae are also parasitized by a wasp.

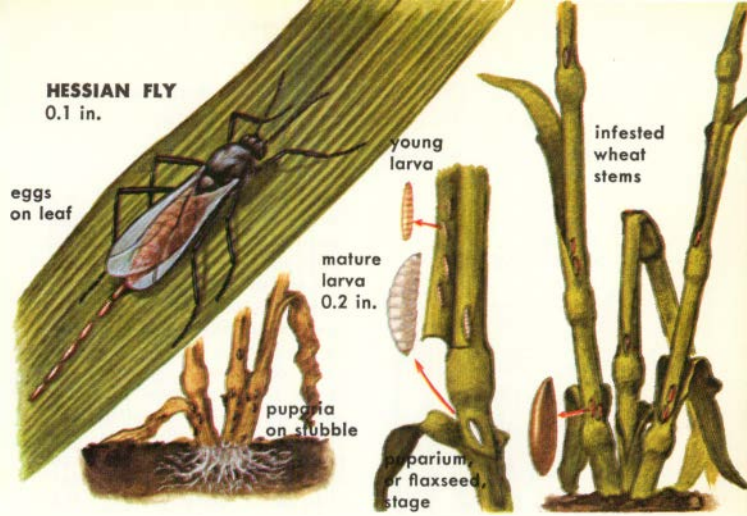


FLY MAGGOTS of only a few species are serious pests of field and forage crops. They damage plants in the same ways as do larval pests of vegetable crops (p. 84). feeding inside the stem, flowers, or seeds.

CLOVER SEED MIDGES winter as larvae in a thin cocoon in the soil or under debris. They enter the pupa stage in the spring and emerge as adult flies in late spring. Within a few days the females deposit eggs in young clover heads, using their long ovipositor to reach deep inside. The developing larvae feed by sucking the sap from the flower parts, thus preventing the formation of seed. When full grown, in about a month, the larvae drop to the ground to pupate. Adults of this generation appear in midsummer and lay eggs that hatch into the overwintering larval forms. The best means of control is cutting the clover before it is in full bloom.

WHEAT STEM MAGGOTS are minor pests of wheat. In the fall they feed in the lower stem of the plant. Their damage is similar to that done by the Hessian Fly (p. 117). In summer the maggots feed near the wheat heads. Infected stems eventually turn white and die. Oats, barley, rye, and other grasses are also attacked. Wheat Stem Maggots overwinter as larvae inside the stem of their food plant. They form pupae in the spring and emerge as adult flies in early summer. A second generation starts in summer, and these larvae overwinter. Crop rotation and destruction of straw in which the larvae are feeding are effective controls.



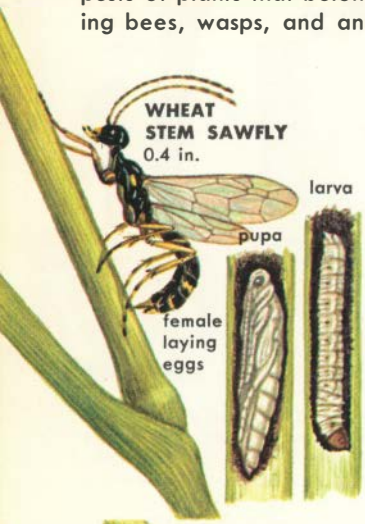


HESSIAN FLIES are the most damaging pests of wheat. They also attack barley, rye, and some species of wild grasses. The feeding of the larvae stunts the plant's growth or kills it if the infestation is heavy. Plants that survive give poor yields. Secondary fungus infections also occur. The life history of the Hessian Fly varies with the region and the wheat-growing method.

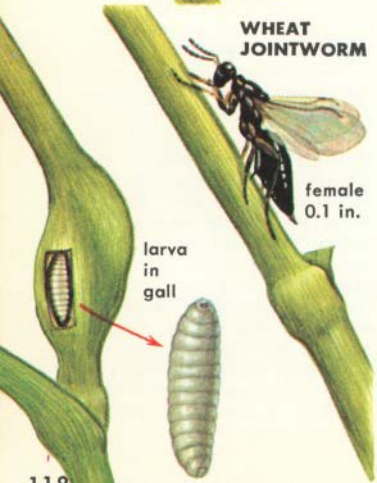
In winter-wheat plantings, eggs are laid on leaves of wheat that come up in late summer or fall, and the maggots move down the leaf to where it joins the stem and begin sucking out the plant's juices. Growth is completed in two to six weeks. The larvae then form pupae in their last larval skin. The flat puparia look like flaxseeds. Adult flies emerge in the spring, and within a few days the females begin laying eggs on the leaves of the wheat plants. Again the larvae feed at the point of juncture of the leaf with the stem and form pupae before the wheat is ready for harvest. Adult flies emerge in late summer and lay eggs that start a second generation on the winter wheat.

Where spring wheat is grown, the second generation is completed earlier, and the flies overwinter also as pupae. If fall planting can be delayed, the flies are unable to lay their eggs on the leaves in time for the larvae to complete development before cold weather. A local agricultural agent can specify the proper time for planting. Volunteer wheat should be destroyed, as should the stubble after a harvest. Resistant varieties of wheat have been developed, and crops should be rotated where possible. Systemic insecticides are now available.

SAWFLIES AND CHALCIDS are among the few insect pests of plants that belong to the large order containing bees, wasps, and ants.



WHEAT STEM SAWFLIES are destructive to wheat and other small grains. The larvae feed inside the stems, working from the top of the plant, where the eggs are laid, toward the bottom. Near the ground level the larvae eat out the inside of the stem completely, causing it to break off. The larvae plug the open base with droppings and then pass the winter in this chamber. Pupae are formed in the spring, and adult sawflies emerge in early summer. The best control is plowing under stubble. Planting corn, legumes, or other crops not attacked by the Wheat Stem Sawfly prevents buildup of pests. Resistant varieties of wheat are available.

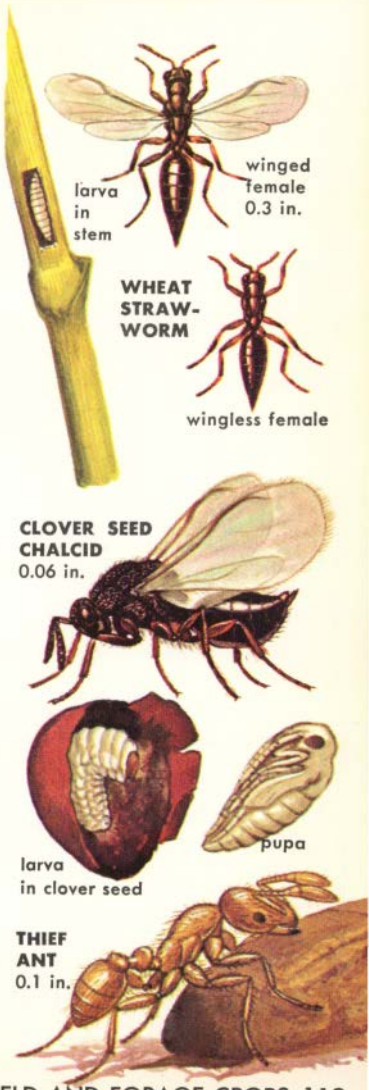


WHEAT JOINTWORM damage is similar to the injury done by the Hessian Fly, causing the wheat plants to break over. The break occurs at a gall-like swelling on the inside of which are the feeding maggots. Adult females have a stiff ovipositor, with which they drill a hole into the stem of a wheat plant just above a joint. Inside the stem they lay from one to two dozen eggs. The feeding of the larvae on the tissues causes the stem to swell and twist. The full-grown larvae remain in the stem, wintering either as larvae or as pupae. Adults emerge in spring. Wheat stubble should be plowed under or burned.

WHEAT STRAW-WORMS have two generations a year. Young plants are attacked in the spring and stunted by larvae that eat into the stem and developing heads. Larvae of the first generation, full grown by May, form pupae in the plant stem and emerge as winged adults by early June. The females deposit their eggs in wheat stems, usually only one egg per stem, and the larvae feed inside through the summer. They pupate in the fall and emerge from the straw or stubble as wingless adults in early spring. They look much like ants. The females lay eggs on young wheat, thus renewing the cycle. Crop rotation is effective. Stubble and volunteer wheat should be plowed under.

CLOVER SEED CHALCIDS destroy the seeds of alfalfa and clovers. The larvae winter inside the seeds on the ground, forming pupae in early spring and emerging as adults in late spring. The tiny adults lay their eggs in the formed but still soft seeds, which then become food for the larvae. Adults are produced from this generation by midsummer, and another generation is started. In warm climates there are as many as three generations. There is no good control for this pest.

THIEF ANTS are not only household pests (p. 24) but may also be field pests. They prefer protein foods, but will eat corn and other seeds. Best control is cultivation of field to break up ant nests.



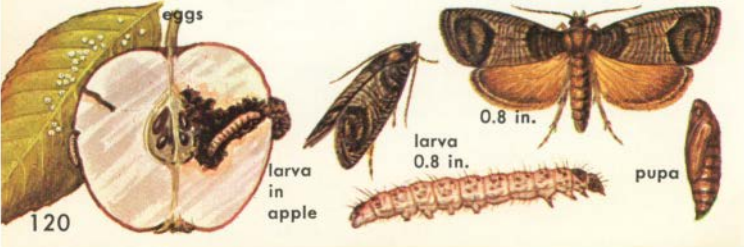
PESTS OF FRUITS AND FRUIT TREES

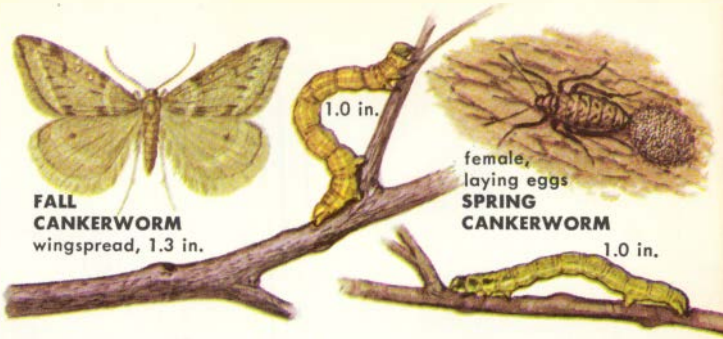
Entire fruit crops are sometimes lost because of insect pests. Some species attack through the roots, trunk, branches, or leaves. Other insects attack only the fruit. Some do damage in only one stage of their life history, while others are pests both as larvae and as adults.

CATERPILLARS of moths and butterflies form the largest group of insect pests attacking fruit and fruit trees. A few caterpillars feed only on the fruit. Many others are leaf feeders.

CODLING MOTHS are the most damaging pests of apples. They also attack pears, quinces, and other fruits. Adults appear in the spring and are active at dusk, the females laying their eggs on leaves, twigs, or fruit spurs. The worms at first feed on the leaves but soon crawl to the developing fruit and burrow inside, feeding near the core and on the seeds. When their growth is completed, usually in about a month, the larvae crawl to the outside and either drop to the ground or crawl down the trunk. They spin a cocoon under debris or loose bark and pass the winter in full-grown larval stage, transforming in spring into pupae and emerging as adults in about two weeks. In most areas there are two generations a year. The first is completed in midsummer; larvae of second generation overwinter.

Control consists of cleaning up debris, including the loose bark on trees, to eliminate places where larvae spin cocoons. Trees can be sprayed with contact insecticides to kill larvae before they enter fruit. Do not spray until petals have fallen from flowers, as early spraying will kill honeybees visiting the blossoms. Do not spray within two weeks of harvest.





CANKERWORMS eat leaves of trees and shrubs, often defoliating them. The caterpillars move with a looping motion. Inchworms and Measuring Worms are other names for these caterpillars. Spring Cankerworms have three pairs of true legs on the thorax and two pairs of prolegs on the abdomen. In crawling, the rear of the body is brought forward so that the hind legs are against the front legs, the center of the abdomen forming a loop. Then the front part of the body is stretched forward full length. If disturbed, worm drops on a silk thread.

Adult moths of the Spring Cankerworm emerge from the pupae in early spring. Males are winged, females wingless. The females lay their eggs in clusters on the bark of trees. As soon as they hatch, the larvae move to the leaves, which are usually just coming out, and begin feeding. After about a month the full-grown caterpillars drop to the ground and pupate, emerging the following spring.

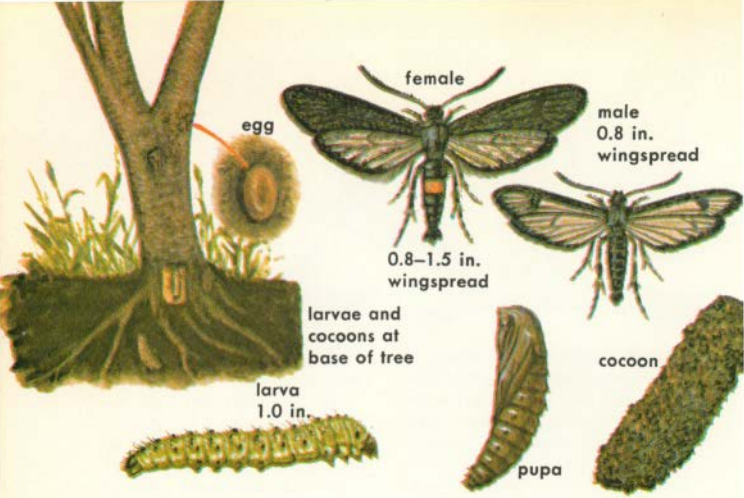
Fall Cankerworms have a similar life history, but the adult moths emerge from the pupae in the fall and lay eggs that do not hatch until spring. The caterpillars have three pairs of prolegs at the end of the abdomen rather than two as in the Spring Cankerworm.

Both pests can be controlled by painting a band of contact insecticide around trunk of tree to kill wingless females that crawl up the trunks to lay eggs. Spray foliage to kill larvae.

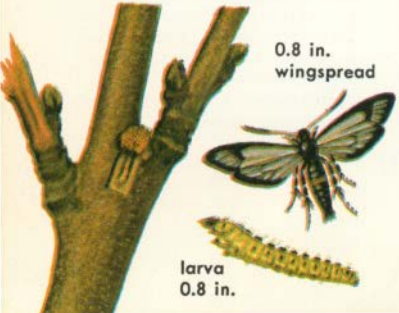
BUD MOTHS of several species feed on the young buds of pear, apple, and other fruit trees. The caterpillars overwinter in silken cases attached to twigs and begin feeding in early spring. They form pupae and emerge as adults by midsummer, starting a second generation. They can be controlled by spraying with contact insecticides.

EYE-SPOTTED BUD MOTH



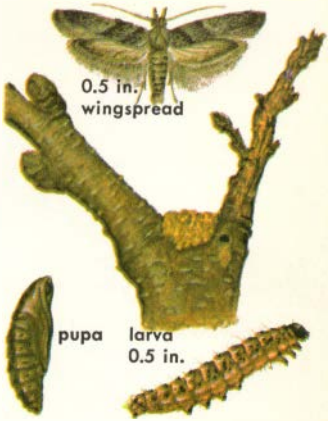


PEACH TREE BORERS are the most damaging pests of peaches. The larvae winter in burrows in the tree trunk, from a foot above the surface to just beneath the soil level. When full grown, the caterpillars change into pupae, spinning a silken cocoon mixed with their excrement and gum from the tree. Adult moths emerge during summer and early fall. Unlike most moths, they fly by day. The females lay their eggs on the trunk of trees, commonly on injured or previously infested trees. The larvae bore immediately into the bark and begin feeding. If an infestation is not stopped, the tree dies. Simple controls are effective, however. The trunk of the tree can be sprayed with a contact insecticide. Or crystals of paradichlorobenzene spread in a circle around the base of the tree trunk and covered lightly with soil will give off a gas and kill young borers in their burrows. Consult an agricultural agent for the best time to apply controls.



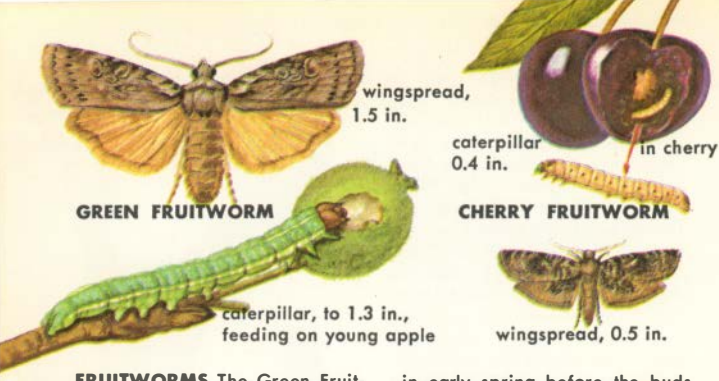
LESSER PEACH TREE BORERS are similar to the Peach Tree Borer in appearance and in type of damage, though they generally attack higher on the trunk or in large branches. To control these pests, injured parts of tree must be sprayed in the fall, after the eggs have hatched. Larvae can also be dug out with a knife, as can Peach Tree Borers.

PEACH TWIG BORERS feed on the new growth of peach twigs, causing them to wilt and die. If a twig dies before a larva completes its growth, the larva moves to another twig. When about half an inch long, the larva spins a cocoon on the branch of a tree and transforms into a moth. Females lay eggs on twigs. As many as four generations are produced in a season, the later generations also attacking fruit. Apply a lime-sulfur or oil-emulsion spray to infested trees to kill larvae in cocoons. Check with your local agricultural agent.



ORIENTAL FRUIT MOTHS, closely related to the Codling Moth, are pests principally of peaches but also attack apples, plums, pears, and other fruits. The full-grown larvae overwinter in silken cocoons attached to the bark of the tree or in debris on the ground. They transform into pupae and emerge as adult moths in the spring. In a few days the females lay their eggs on leaves or twigs. The larvae of the first generation feed on the young twigs, causing them to die. In about a month the larvae are full grown. They spin cocoons, pupate, and emerge as adults about a week later. In the South there are as many as seven generations a year; in the North, four. Later generations feed inside the fruit. Oriental Fruit Moths are controlled to some degree by an introduced wasp that parasitizes the caterpillars. Many overwintering larvae can be killed by cultivating the orchard in the spring. Apply contact insecticides to the trees approximately every three weeks.





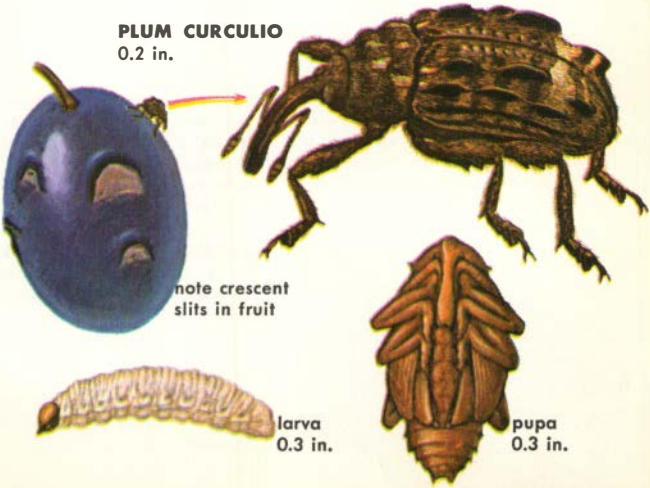
FRUITWORMS The Green Fruitworm, though seldom abundant, feeds on apples and other fruits or on tender foliage and buds. The larvae, usually full grown by June, crawl down the tree and transform into the pupal stage in a silken cocoon in the soil. The adult moths emerge in late summer or fall and hibernate in winter. They die the following spring after mating and laying eggs. The worms can be killed with contact insecticides applied in early spring before the buds have opened. The Green Fruitworm occurs in eastern U.S.; the Cherry Fruitworm, similar in habits, mainly in the Northwest. Cherry Fruitworm larvae feed inside cherries until full grown. They hibernate under the bark and transform into pupae in the spring. Adult moths emerge in early summer, and females lay their eggs on developing fruit. Trees should be sprayed with a contact insecticide at this time.



LEAF ROLLERS eat leaves, green twigs, and buds, injuring many kinds of trees and shrubs (p. 93). Species that attack fruit trees feed on the developing fruit. Fruit-tree Leaf Roller caterpillars hatch in the spring from eggs laid on the bark or twigs the previous fall. They pupate in a roll of leaves held together with silk. The adult moths emerge in midsummer, and within a few days the females lay eggs. The most successful control is obtained with the use of an oil-spray insecticide applied to each of the brownish egg masses on the bark or twigs.

WEEVILS that damage fruit or fruit trees do so both as adult beetles and as larvae, or grubs. Many kinds of weevils are pests also of vegetables (p. 78), field and forage crops (p. 105), and stored products (p. 146).

PLUM CURCULIOS are pests of apples, cherries, peaches, plums, and other stone fruits. Adults hibernate beneath trash under trees and in early spring feed on buds and young leaves. The female chews a hole in a developing fruit, then lays an egg inside. The beetle uses her snout to push the egg deep into the hole. Finally she cuts a crescent-shaped slit in the skin of the fruit below where the egg is laid. Hundreds of eggs may be laid in one fruit; the spots and crescents are a telltale sign of an infestation. The eggs hatch in about a week, and the grubs burrow into flesh toward the stone or seeds, around which they feed. The fruit usually drops before the larvae are full grown. When the larvae reach full growth, they emerge and burrow into the soil to pupate. Adults appear in midsummer and feed on fruit on the ground until cold weather, when they hibernate. Orchards should be cleaned of trash under which the adults might hibernate. Plow or disk the orchard in early summer to kill the pupae. Destroy any dropped fruit. Spray the trees with a contact insecticide after they have bloomed.





larva
in
apple

APPLE FLEA WEEVIL
0.1 in.

APPLE CURCULIO
0.2 in.





APPLE CURCULIOS are similar to Plum Curculios in the damage they do to fruit. The Apple Curculio has a much longer snout and a broader body. Females do not make crescent-shaped scars on the fruit when they lay eggs, and the larvae pupate inside the fruit. The fruit becomes stunted, knotty, and mummified. In heavy infestations fruit drops before ripening. Adults emerge in midsummer and feed until cold weather, then hibernate under debris until spring. Best control is a thorough cleanup of the orchard when an infestation is discovered. Chemical controls are difficult, as beetles feed deep in fruit. A variety of the Apple Curculio attacks cherries.

APPLE FLEA WEEVILS are pests mainly in the Midwest. Adults feed on buds and young leaves in the spring. The grub, or larva, mines through the leaf tissues. At the edge of the leaf the larva forms a blister-like cell in which it transforms into the pupa. Adult beetles appear in late May or June, feed on the foliage for a few weeks, and then become inactive through the summer. They hibernate in winter and begin feeding again in early spring. Contact insecticides applied beneath the trees will kill many of the hibernating adults in the fall, or trees can be sprayed in early spring. Check with your agricultural agent for the best time for spraying locally.

IMBRICATED SNOUT BEETLE



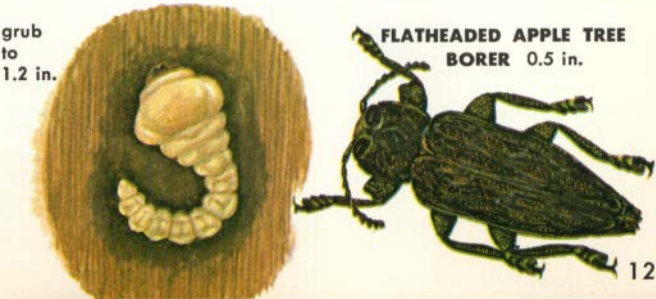
IMBRICATED SNOUT BEETLES eat buds, young fruit, and leaves of apples and other fruit trees. Adults appear in June, feed for several weeks, then become inactive until spring. The larvae feed in roots of legumes and other plants. Control is by the same methods used for Apple Flea Weevil.

BORERS that feed on the inner bark and sapwood of fruit and shade trees are the grubs, or larvae, of beetles. Usually they attack only the young or injured and already weakened trees.



ROUNDHEADED APPLE TREE BORERS burrow into apple, pear, and other trees. The soft-bodied grubs have an enlarged, round area just behind their head and make round tunnels. Small trees are girdled and killed. Two (sometimes three) winters are spent as grubs. Full-grown grubs pupate in spring, and adults emerge in early summer. They feed on leaves and twigs but do little damage. Females lay eggs in slits cut in bark at base of trunk. Young grubs usually work near soil line; older grubs feed higher, bore deeper. Dig grubs from burrows with knife or wire probe or fumigate burrows. Contact insecticides kill adults.

FLATHEADED APPLE TREE BORERS attack nearly all kinds of trees and shrubs. The grubs burrow through the inner bark and sapwood and are especially damaging to young trees. The grubs, which work mainly on the sunny side of the tree, have a flattened enlargement just behind the head. The grubs hibernate in their burrows, which are filled with excrement and sawdust. They form pupae in the spring and emerge in early summer. Like the larvae, the adult beetles congregate on the sunny side of the tree, the females laying their eggs in cracks in the bark. The trunks of young trees should be wrapped in paper or cloth. Borers can be dug out.





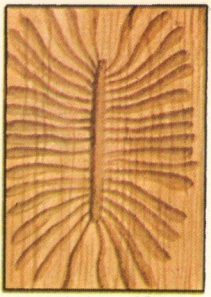
0.1 in.



larva
0.1. in.



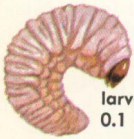
"shot holes" in wood



tunnels branching from parent gallery

SHOT-HOLE BORER

SHOT-HOLE BORERS tunnel in the inner bark of fruit and shade trees. The grub tunnels are branches from a parent gallery, about two inches long, in which the female beetle laid her eggs. When full grown the grubs form pupae at the end of the tunnel, and the adults bore straight out through the bark, making the identifying "shot holes." The adult beetles fly from tree to tree. Females usually lay eggs in an already injured tree. The leaves of an infested branch turn yellow and drop; small trees are killed. Infested trees should be sprayed with a contact insecticide in late spring, when the adults are emerging, or in the fall, when the adults are laying eggs. Healthy trees are seldom attacked, as the females cannot find places to enter to lay eggs. The beetles overwinter in the grub stage.

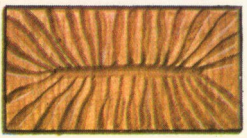


larva
0.1 in.



0.1 in.

PEACH BARK BEETLE



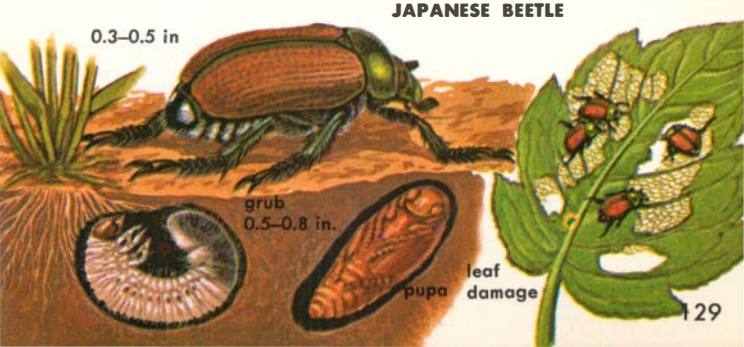
parent gallery and tunnels

PEACH BARK BEETLES are closely related to the Shot-hole Borer and their damage is similar. The parent gallery runs across the grain of the trunk; the Shot-hole Borer's gallery runs with the grain. Peach Bark Beetle grubs tunnel with the grain; Shot-hole Borer grubs work across the grain. Peach Bark Beetles are controlled by the same methods used for the Shot-hole Borer.

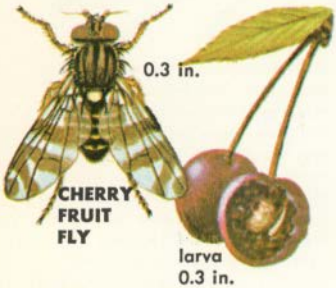


SINUATE PEAR TREE BORERS tunnel through the inner bark of pear, hawthorn, and other trees. The larvae, or grubs, hibernate in the burrows, which cause the bark of the tree to split and darken. Full-grown grubs pupate in the spring and emerge in early summer as adults. The beetles feed on the foliage but do little damage at this stage. The females lay their eggs in cracks in the bark, and the grubs bore inside. Two years are required to complete a life cycle. Young trees are commonly killed. Dead or infested limbs should be cut off and destroyed. Trees should be sprayed twice —late May and early June.

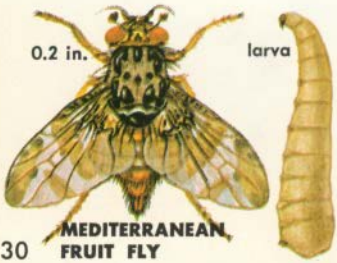
JAPANESE BEETLES feed on the foliage of many kinds of shade and fruit trees and also destroy fruit. Many beetles congregate on one plant. The grubs are major pests in lawns and greens, feeding on grass roots. In most areas two years are spent as grubs. The larvae then pupate in the soil, emerging as adults in midsummer. Adults are killed with contact-insecticide sprays or lured to traps. Grubs are killed by treating the soil with insecticides and also with "milky spore" (p. 13).



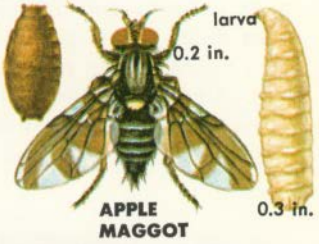
MAGGOTS, the larvae of flies, are sometimes serious pests of fruits. Maggots feed deep inside fruit; hence to be effective controls must be applied when the adults are laying eggs.



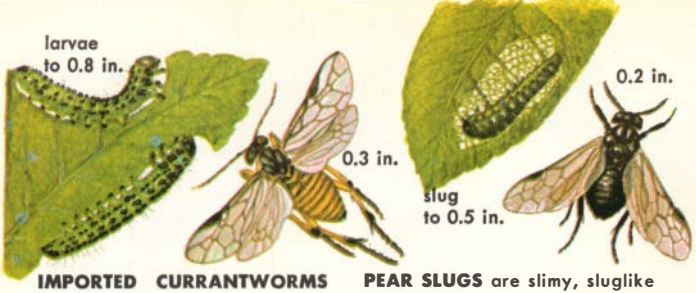
APPLE MAGGOTS tunnel through apples, blueberries, and other fruits, reducing the flesh to a brown, decaying pulp. When full grown—and usually after the fruit has dropped—the maggots emerge and pupate in debris or in loose soil. Adults appear in late June or July the following summer. In about ten days the females lay their eggs in fruit, puncturing the skin with their sharp ovipositor. Lead arsenate or contact insecticides are effective. An agricultural agent can advise best time to spray.



CHERRY FRUIT FLIES infest pears, plums, and other fruits as well as cherries. The maggots hatch from eggs laid in slits cut in the fruit by the female flies. They feed on the flesh of the fruit and cause it to be dwarfed, misshapen, or decayed. When full grown, the worms drop to the ground and pupate in loose soil or under debris. Adults emerge late the following spring and feed on leaves or developing fruit by scraping surface and sucking juices. Stomach-poison or contact insecticides, applied in spring are effective.



MEDITERRANEAN FRUIT FLY larvae feed on citrus fruits, peaches, plums, and other fleshy fruits. This dangerous pest has gained entry to continental U.S. several times through introductions in Florida, but each time has been exterminated. Mexican Fruit Fly has been kept in check by inspection and control along Texas-Mexico border.



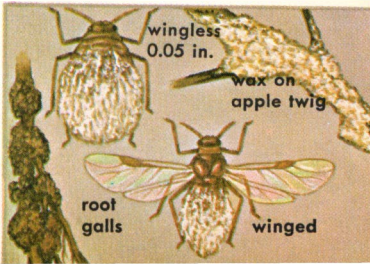
IMPORTED CURRANTWORMS hatch from eggs laid on the leaves of currant or gooseberry bushes. The larvae eat from margin of leaf toward center. When full grown, they drop to the ground to pupate. In warm regions there are two and a partial third generation every year.

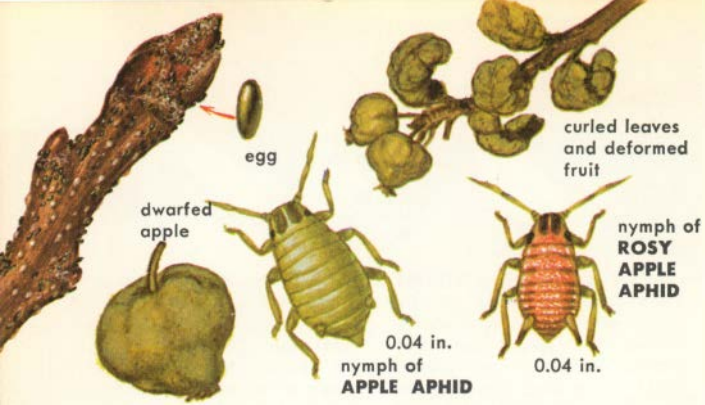
PEAR SLUGS are slimy, sluglike larvae that eat the foliage of pears, plums, cherries, and other fruit trees. Only the veins of the leaves remain. The full-grown worms pupate in the soil. A second generation appears in midsummer, in heavy infestations completely defoliating trees.

SAWFLY LARVAE are leaf feeders (p. 95) attacking many plants. They are easily killed with stomach-poison or contact insecticides.

APHIDS, or plant lice, are all similar in habits and life history, which is often complex (p. 66). All are injurious pests of plants, and some species are especially injurious to fruits.

WOOLLY APPLE APHIDS secrete a woolly, white wax over their body as they feed. They overwinter either in the egg stage in crevices on the bark of elms or as nymphs hibernating on roots of apple trees. Nymphs that hatch from the eggs on elms feed on the leaves and buds. In the third generation winged forms appear and migrate to apple trees, where they feed on roots, causing galls to form. Sometimes they stay on the roots for two seasons, through several generations. They stunt the tree's growth and may kill it. These pests are difficult to control. Stomach-poison or contact insecticides are effective if applied heavily. An introduced wasp parasite is also effective.





APPLE APHIDS overwinter as eggs on the bark of trees. Nymphs hatch in early spring and feed first on buds. A contact insecticide applied at this time gives good control, especially since all of the eggs hatch at about the same time. Trees can be sprayed a second time in late summer to kill winged adults that may have migrated from nearby orchards or from wild host trees.

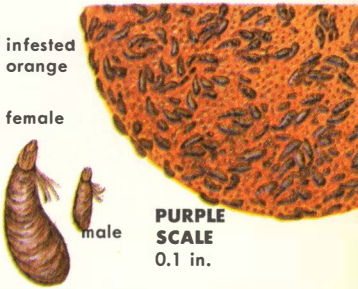
ROSY APPLE APHIDS are pests principally of apples but may also infest pears, hawthorns, and such nonwoody plants as plantains. Leaves and twigs of an infested tree curl and the fruit becomes hard and knotty. The eggs hatch over a period of several weeks in early spring about the time the trees begin to bud. Dormant oil sprays (p. 22) will destroy both the eggs and newly hatched nymphs.



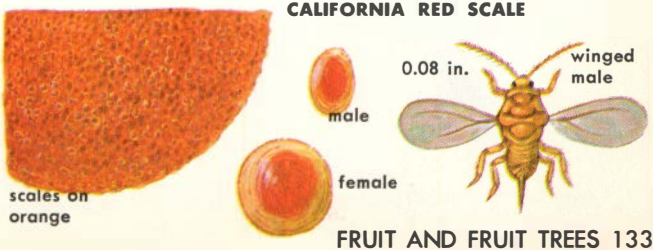
SPIREA APHIDS collect in large numbers on the new growth of spirea and other plants. Also known as the Green Citrus Aphid, this species commonly attacks citrus in Florida and California. It causes leaves to curl, deforms fruit, and covers the ground with honeydew, on which black sooty mold grows. It also transmits a virus disease. Winged forms, produced whenever a colony becomes crowded, migrate to other trees. Use contact insecticide sprays in early spring, before the population of aphids has built up.

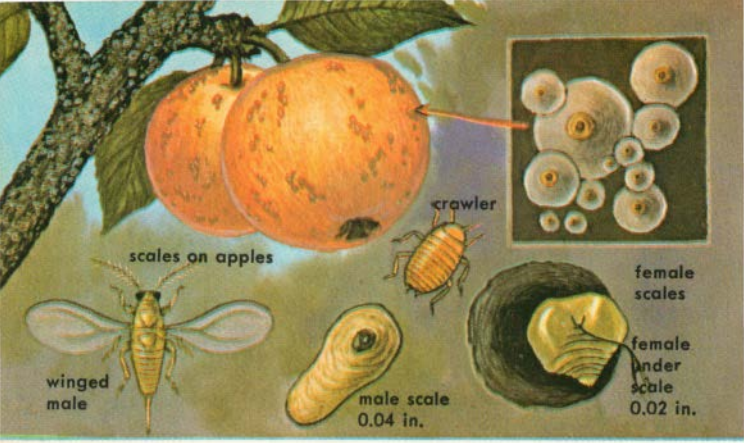
SCALES AND MEALYBUGS are so modified in body form that they are often not recognized as insects (p. 86). All of the thousands of species damage plants by feeding on their juices, thus stunting their growth and deforming the fruit. Scales and mealybugs are the most destructive insect pests of citrus.

CALIFORNIA RED SCALE is the most damaging scale pest of citrus in California, occurring less abundantly in Texas, Arizona, and the Gulf states. California Red Scale is also a pest of many other fruit trees and ornamentals. It feeds on the stems and leaves as well as on the fruit. Nymphs crawl over the plant for several hours before settling to feed and secreting a waxy covering over their body. Males mature in about two months and emerge from scale as yellow-winged adults. Each inseminates an immobile female, then dies. Fertile females give birth to two or three young every day for several months. Four generations are produced every season. Trees are fumigated with hydrogen-cyanide gas or are sprayed with a contact insecticide to kill the "crawler" nymphs.

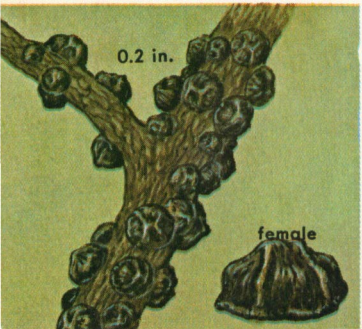


PURPLE SCALE, a widely distributed species, is the most damaging citrus scale pest in Florida. It also occurs in California. In addition to citrus, this scale infests avocados, pecans, and many ornamentals. In Florida, controlled by spraying with oil to kill the young still crawling and before they secrete a protective armor. Parathion and other contact insecticides are used in California.





SAN JOSE SCALE is damaging to apple, pear, peach, cherry, and many other fruit and shade trees and ornamental plants. Heavy infestations may kill the trees, which are first weakened and their foliage yellowed. Infested fruit is spotted. San José Scales overwinter as partly grown nymphs, or crawlers, that cling to the bark of the tree. They begin to feed in early spring, as soon as the sap starts to flow, and are full grown by the time the trees bloom. The winged males inseminate the females, which never emerge from under their scale. Females give birth to as many as 500 nymphs in 1½ months. The tiny mitelike crawlers move over the plant for several hours before settling to feed, secreting a waxy scale over themselves. In the crawling stage they may be blown by the wind or carried by man or other animals to infest other plants. As many as six generations are produced each year. A dormant spray in late winter or early spring kills overwintering nymphs. Wasp parasites also effective.



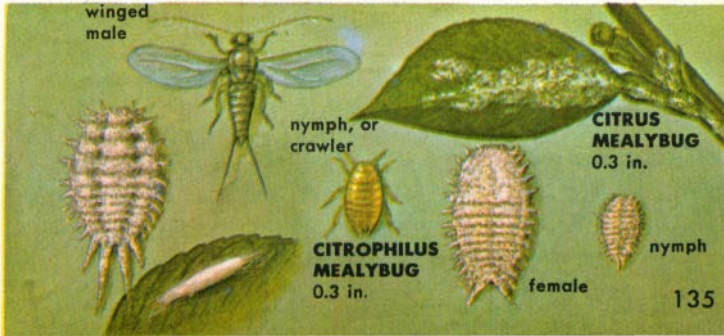
BLACK SCALE infests citrus, apples, figs, grapes, pears, and many ornamentals in warm regions and is also a greenhouse pest in cold climates. In addition to the damage done by sucking the plant's juices, large amounts of honeydew are excreted on which sooty mold grows. Controlled principally with oil sprays. An introduced wasp parasite is also effective.

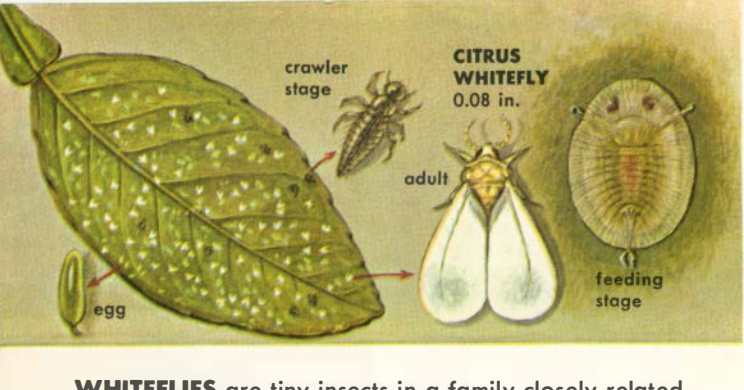
COTTONY-CUSHION SCALES are pests of citrus and many other fruit trees and ornamentals. The female, which has a brown or reddish body, secretes a large cottony mass containing as many as 1,000 red eggs. Both the young and the adults can move, although the female stops moving after her egg sac forms. The tiny males are winged.

Cottony-cushion Scale, once the most damaging pest of citrus in California, was brought under control by Vedalia, a predatory lady beetle introduced from Australia. The use of insecticides to kill other pests has destroyed the Vedalia in some areas, where insecticides must be used now to control the Cottony-cushion Scale until the beetles are again established.

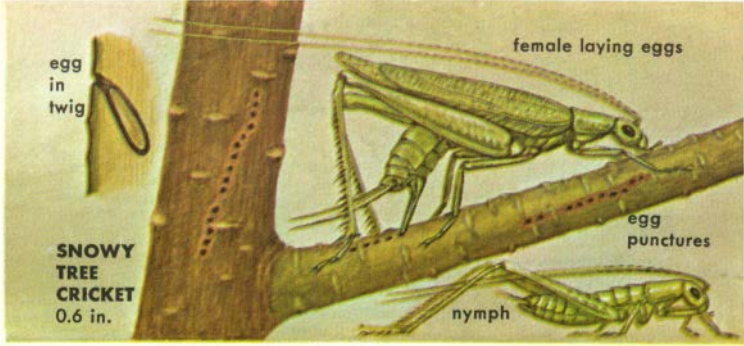


CITRUS MEALYBUGS suck the juices from the leaves, stems, and fruit of citrus and many other plants. In warm climates they are outdoor pests, sometimes infesting potatoes and vegetable crops. In cool climates they are pests of house plants and in greenhouses. Citrus Mealybugs expel large amounts of honeydew. Females are covered with wax; males are winged. On small plants they can be picked off by hand, washed off with water, or killed with contact insecticides. In groves lady beetles and parasitic wasps have been effective controls for Citrus and related Citrophilus, Grape, and Long-tailed mealybugs.





WHITEFLIES are tiny insects in a family closely related to aphids and scale insects. Two dozen or so species, including the Greenhouse Whitefly (p. 88), are damaging to ornamentals and fruit trees, particularly citrus and other plants that grow in warm climates. Fruit on an infested tree is discolored by sooty mold. If an infestation is allowed to persist, the plant's growth is stunted and its yield is greatly reduced. All whiteflies have a similar life history. The female lays her eggs on short stalks attached to the underside of leaves. The nymphs hatch in 4–12 days and are called "crawlers" because they move about over the plant. Soon, however, they insert their beaks into a stem or leaf and begin to feed on the plant's juices. When the nymphs shed, they lose their legs and their antennae are greatly reduced in size. At this stage the nymphs are immobile and resemble scales. On the fourth molt the adults emerge. Both males and females are winged and are covered with white, powdery scales. As many as three or four generations are produced in a season in warm climates. Infested plants should be sprayed in spring and fall with an oil emulsion or with a contact insecticide, such as malathion or parathion. Consult local agricultural agent for best time to spray.



TREE CRICKETS lay eggs in the branches or stems of trees and shrubs. The female drills a hole, lays an egg, then moves forward and repeats the process, sometimes laying several dozen eggs in a row. The stem beyond the punctures usually dies. Spray with lead arsenate or other stomach poison in summer before egg laying begins. Remove and burn punctured stems in the fall.

CITRUS THRIPS is a serious pest in California but does not occur in Florida. It feeds on buds, new growth and young fruit, scraping away outer tissues and sucking up juices. Infested trees grow slowly and fruit shows distinct ring scar. Thrips winter in the egg stage on leaves and stems. A life cycle is completed in about three weeks or less. Both stomach-poison and contact insecticides are effective.



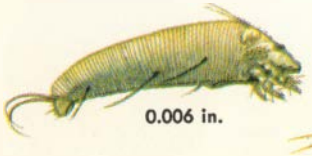


CITRUS RED MITES, called Purple Mites in Florida, cause the leaves of infested trees to be speckled, finally turning brown and dropping. The fruit is discolored. The Citrus Red Mite is an especially serious pest in California. Six-spotted Mites are more abundant in Florida. They collect on underside of leaves.

MITES, relatives of spiders and ticks, have become more serious pests in recent years. Some of the newer insecticides kill the predators and parasites of mites. Only those mites especially damaging to citrus are described here. Other pests include the European Red Mite, Pacific Spider Mite, and Pear Leaf Blister Mite, which infest pear, cherry, apple, and other fruit trees of temperate regions. Mites are also pests of man (p. 45), domestic animals and pets (pp. 54–55), vegetable crops (p. 85), and flowers and shrubs (p. 90). Oil sprays, sulfur dusts, and lime-sulfur sprays are effective controls, as are special miticides. Your agricultural agent can tell you the best chemical and time of application in your area.

CITRUS BUD MITES, pests mainly in California, feed on buds and blossoms of lemons, less commonly on other citrus. Fruit leaves and twigs are deformed.

CITRUS RUST MITES, serious pests in Florida, damage mainly oranges but also injure grapefruit, limes, and lemons. Females lay eggs on fruit and leaves.



PESTS OF FOREST AND SHADE TREES

Insect pests destroy more timber than do forest fires. Ordinarily the damage is not conspicuous, but in severe outbreaks whole stands of timber may be killed in one season. Some species spread plant diseases. State and national government agencies battle forest insects in large-scale control programs.

BEETLES are damaging to trees both as adults and as larvae (grubs). Most injurious are the borers that work in the wood of the trunk or in the branches.

SMALLER EUROPEAN ELM BARK BEETLE



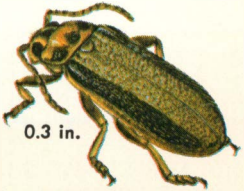


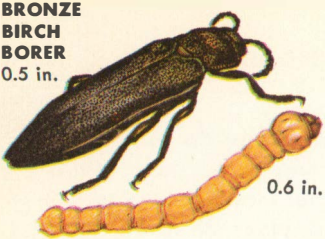
ELM BARK BEETLES are carriers of the deadly Dutch elm disease, caused by a fungus. The Smaller European Elm Bark Beetle was introduced to North America in 1909, the disease in 1930. The Native Elm Bark Beetle is now also a carrier. Adults of both species appear in late spring or early summer and feed on branches or twigs. Eggs are laid only in dead or dying wood. Keeping trees healthy and eliminating damaged or diseased portions gives partial control.

ELM LEAF BEETLES overwinter as adults and in early spring lay clusters of eggs on underside of elm leaves. Grubs and adults feed on leaves. Grubs are full grown in about three weeks. They pupate in debris under tree and emerge as adults in about two weeks. Three or more generations are completed in a year. Spray leaves with stomach-poison or contact insecticides to destroy grubs and adults, and at base of infested tree to kill grubs descending to pupate.

ELM LEAF BEETLE



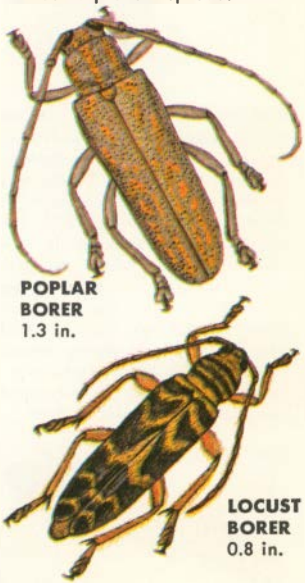


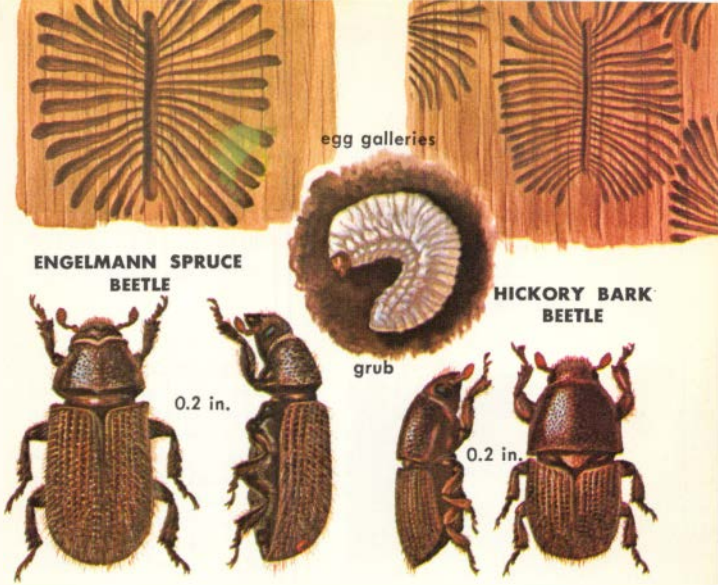


BRONZE BIRCH BORERS are mainly injurious to birches but may also attack willows, poplars, and cottonwoods. The larvae overwinter in the sapwood, forming pupae in early spring and emerging as adults in late spring or early summer. Females lay their eggs in crevices in the bark. On hatching, the grubs immediately burrow into the wood. Their tunnels, sometimes 4 feet long, may cut off the flow of sap. First the tips of the branches turn brown, then the tree dies. The Bronze Birch Borer, related to the Flatheaded Apple Tree Borer (p. 127), is most likely to attack sick or injured trees. Use contact insecticides for adults.

LOCUST BORERS winter as small larvae in the bark and start their tunneling into the wood in spring, causing swollen areas to appear on the trunk. The borers commonly kill the tree. Full-grown grubs pupate in cells in the wood in midsummer. Adult beetles appear in late summer or early fall. They fly actively, feeding on flowers. The females lay their eggs in cracks in bark, most often attacking small or weakened trees. Spray trunks with a contact insecticide before tree starts spring growth.

POPLAR BORERS are long-horned beetles. The grubs tunnel in the trunk and large limbs of trees, weakening the wood so that limbs break off. Eventually an infested tree dies. Larvae are usually full grown in two years but may take three years to complete development. They pupate in the burrows and emerge as adults in late summer or early fall. The female beetle deposits eggs in cracks in the bark. The newly hatched grubs immediately burrow inside. Larvae can be killed with probes or by fumigating tunnels with carbon bisulfide (see Roundheaded Apple Tree Borer, p. 127). Badly infested trees should be cut and burned to prevent spread.

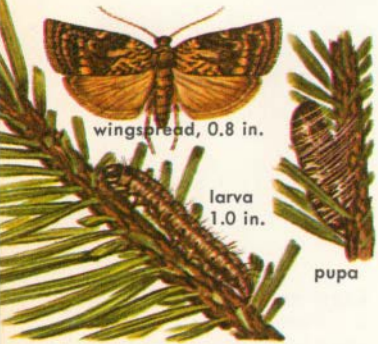




ENGELMANN SPRUCE BEETLES bore through the outer bark of living trees, cutting egg galleries parallel to the surface. Each gallery contains about 125 eggs. The grubs feed on the wood near the chamber until cold weather, rest until spring, then feed again. They pupate in midsummer and become adults in late summer or fall, spending the winter under the bark of the girdled and dying or dead trees. The following spring the beetles infest new trees. Normally the beetles are controlled by natural predators. Foresters check constantly for infestations. Bark of infested trees is peeled off and burned, or trees treated with a penetrating insecticide.

BARK BEETLES of several species damage conifers, and less commonly, deciduous trees. Among these are the Hickory Bark Beetle, Douglas Fir Engraver, Western Pine Beetle, and Southern Pine Beetle. Typically the beetles mine, or tunnel, just beneath bark to make galleries for eggs. More extensive tunnels ramify from galleries as the grubs feed. Sap occasionally flows from tunnels, and dust of borings collects around base of tree. Tunnels open way for fungus diseases, and destruction of cambium eventually kills tree. In street and yard plantings, prune dead wood of trees to destroy breeding places. Kill adults with contact insecticide.

CATERPILLARS, the larvae of moths and butterflies, feed on the leaves, buds, and flowers of many kinds of trees and shrubs. Certain species of moths are among the most damaging pests of forests. Control of the most serious pests may involve several states or an entire region. Such large-scale control programs are conducted by state and federal agencies. Infestations of shade trees may be controlled locally.



SPRUCE BUDWORM

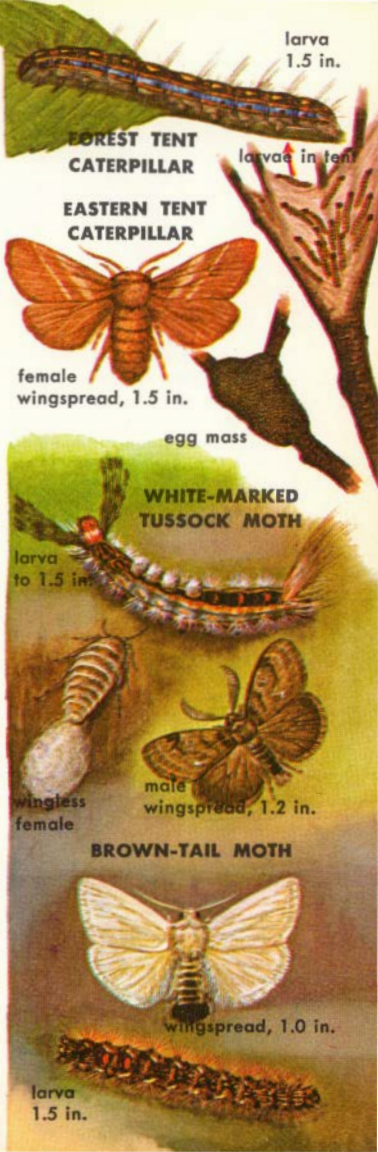
SPRUCE BUDWORMS, of the conifer forests of eastern United States and Canada, are among the most injurious of all insect pests. Young caterpillars overwinter beneath bark and become active in early spring, feeding on buds and new growth. They are full grown by early summer, forming pupae and transforming into adults. Moths lay eggs in late summer. Heavy infestations kill trees; light infestations turn needles brown. Control with stomach-poison or contact insecticides.

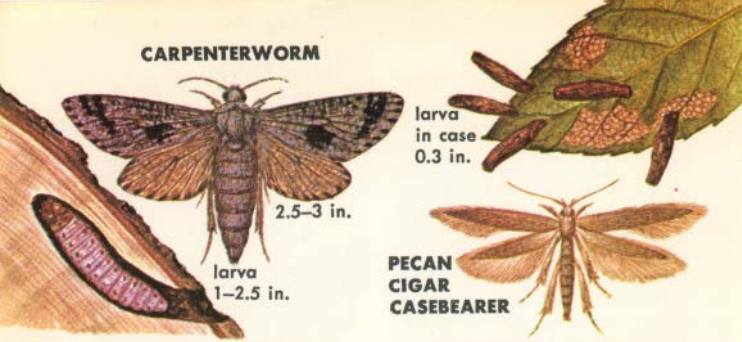


GYPSY MOTH caterpillars feed on leaves of deciduous trees, conifers, and many other plants. They form pupae in midsummer and emerge as adults in July and August. The Gypsy Moth overwinters in the egg stage. As the females cannot fly well, the Gypsy Moth is spread long distances principally by man—on cars, trucks, trains, or other vehicles. The caterpillars spin silken threads and may be blown by the wind. Egg masses can be destroyed or the trunks of trees treated with a contact insecticide to kill caterpillars.

FOREST TENT CATERPILLARS at times migrate in armies of millions, defoliating trees and shrubs in their path. They usually feed on the leaves of oaks, maples, elms, ash, and conifers. Winter is passed in the egg stage, and the larvae hatch in early spring. Adult moths appear in midsummer. Forest Tent Caterpillars, despite their name, do not make tents, as do the closely related Eastern Tent Caterpillars. Foliage of infested trees can be sprayed with a stomach-poison or contact insecticide to kill caterpillars.

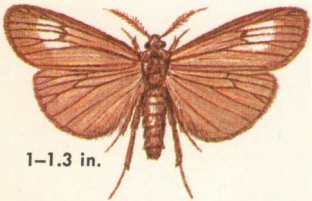
TUSSOCK MOTH caterpillars are hairy and usually have several long tufts of black hairs on the head and tail. The caterpillars hatch in late spring from egg masses laid on bark and leaves or on the cocoon case from which the nearly wingless females emerged. They feed on the foliage of a great variety of trees and shrubs and are full grown by midsummer. In many regions there are two generations a year. Egg masses can be painted with creosote or gathered and burned. The larvae can be killed with stomach-poison or contact insecticides. The White-marked Tussock Moth is a common and widespread species; others are the Hickory Tussock Moth, Douglas Fir Tussock Moth, and Western Tussock Moth. The Gypsy Moth (p. 142) and the Brown-tail Moth belong to the same family. The Brown-tail Moth, once a damaging pest in eastern United States, is now largely under control.





CARPENTERWORMS burrow into the wood of oaks, elms, maples, and other deciduous trees. The holes weaken the trees so that limbs break off in heavy winds. The damaged wood is greatly reduced in value. The full-grown larvae pupate in the wood. When it is time for the adults to emerge, the pupae wriggle their way partly out of the tree. The adult moth leaves the shed pupal skin in the hole. Each generation requires three years or longer. Best control is fumigation of burrows.

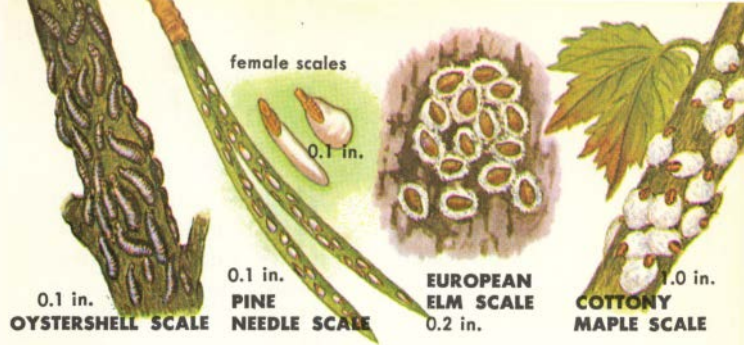
CASEBEARERS are a family of moths in which the caterpillars build portable cases carried with them as they feed. The caterpillars can be killed by spraying the foliage with either stomach-poison or contact insecticides. Some species are especially damaging to fruit trees, others to shade or forest trees. Many attack only one kind of tree. The Pecan Cigar Casebearer is a pest of pecan, hickory, and walnut trees in eastern U.S., the California Casebearer damages willows in California.



CALIFORNIA OAKWORM

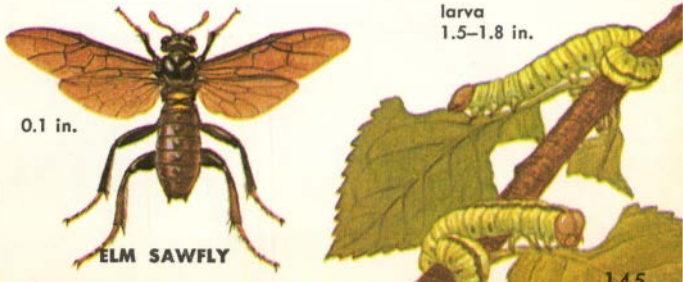
OAKWORMS are foliage feeders. The California Oakworm is a pest of live oaks in California. The Orange-striped Oakworm, of a different family, infests oaks of eastern U.S. Both will feed on other deciduous trees. In warm regions there may be two generations a year. Spray with stomach-poison or else with a contact insecticide.





SCALES that injure forest and shade trees are similar in life history to species damaging flowers and shrubs (p. 86) and citrus (p. 133). In heavy infestations the foliage turns brown and drops. Young plants may be killed. Oystershell, Pine Needle, Cottony Maple, and European Elm scales are common, widespread species. Scales are killed by applying a dormant oil spray before the plant buds in spring or by spraying with a contact insecticide when scales are in the crawling stage.

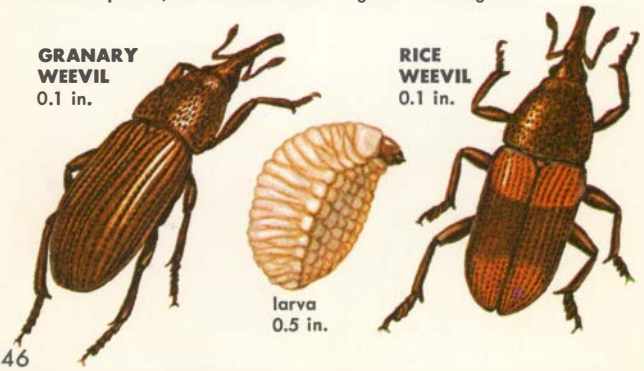
SAWFLY larvae look like caterpillars, though the adults belong to the same order of insects as bees, wasps, and ants. The larvae feed on foliage. Some species damage shade and forest trees. Kill larvae by spraying with either stomach-poison or contact insecticides when they are actively feeding.

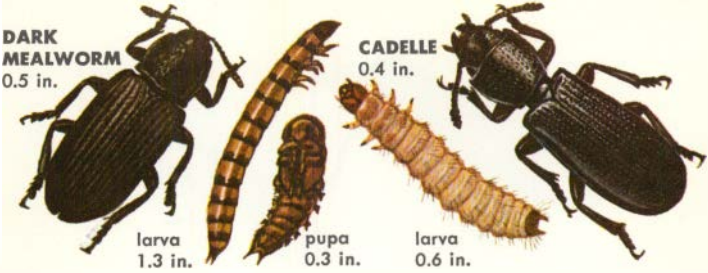


INSECT PESTS OF STORED PRODUCTS

Pest infestations in stored products are difficult to detect and control. The pests not only eat the grain or other stored products but may also create damp, warm conditions in which equally destructive molds can grow. Cheese, cured meats, furs, and wool fabrics are among the animal products attacked by insect pests. Other pests of stored products are described in the section on Household Pests (p. 24).

WEEVILS may destroy an entire storage of grain. Most damaging and widely distributed are Granary and the Rice weevils. The Granary Weevil does not fly, hence does not infest grain in the field. It thrives in northern climates; the Rice Weevil is most abundant in warm climates. The Rice Weevil can fly and often infests grain before storage. Adults of both species will eat whole grain or grain products. The larvae can develop only in whole kernels, in sizable pieces, or in flour that has become moist and caked. A life cycle is completed in one to two months, and the weevils overwinter either as larvae or as adults. Each female lays about 400 eggs in her lifetime. She chews a hole in a kernel and then deposits one egg inside. Adults live two years or longer and can survive long periods without food. In households, infested products should be burned, and the storage area cleaned thoroughly. Similar sanitary measures are taken in granaries, or the grain is fumigated.

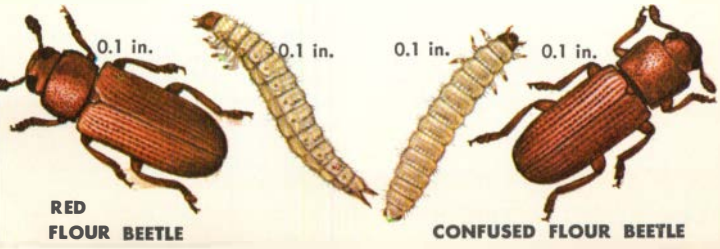




MEALWORMS feed on all types of grain and grain products, particularly if stored in dark, damp places. After six to nine months, larvae form pupae in grain and transform into adults. Yellow Mealworms are more abundant in cool climates, Dark Mealworms in warmer climates. In storage bins or elevators, larvae are killed by superheating, freezing, or fumigation.

CADELLES are beetles that infest grains and seeds in storage. The larvae feed on the grain, but the adult beetles attack and eat other inescts or their larvae. Both the eggs and pupae are killed by low temperatures, but the adults and larvae survive long periods of cold. The adults and larvae tunnel into soft wood in storage areas and are most easily killed by fumigation.

FLOUR BEETLES feed on grain or grain products, spices, nuts, dried fruits, chocolate, and other stored foods. They give flour a disagreeable, moldy flavor. The Red Flour Beetle is most abundant in warm regions, the Confused Flour Beetle in cool climates. Both are worldwide in distribution and are among the most familiar of the stored-product pests to reach the home from the grocery store. Note that the Red Flour Beetle's antennae are enlarged abruptly, while the Confused Flour Beetle's antennae enlarge gradually. In the house, infested products should be destroyed and cupboards cleaned thoroughly. If a product must be saved, larvae can be killed if kept for several hours at 40 degrees F. or if heated to about 130 degrees F. for two hours. Destroying flour is usually most practical.





SAW-TOOTHED GRAIN BEETLES, worldwide in distribution, feed on a wide variety of foods but especially on flour, cereals, and other grain products. The beetles are so flat they can crawl into sacks or boxes that appear to be tightly sealed. The females deposit their eggs in the food, and when full grown, the larvae form pupae and transform into adults. A life cycle usually takes about two months, with six or seven generations a year. All life stages are killed by cooling to 0 degrees F. for one day or heating to 125 degrees F. for an hour. Clean storage areas. Avoid contaminating foods with insecticides.

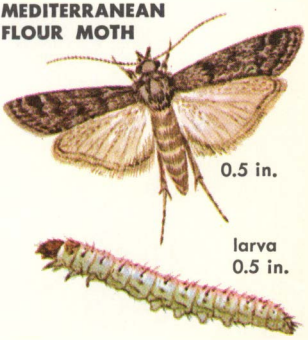


ANGOUMOIS GRAIN MOTH caterpillars attack grain in storage and also in the field. They prefer tender, damp grain rather than grain that is hard and dried. The larvae tunnel into the kernels and seal the entrance holes with silk. When full grown the larvae spin a cocoon in the cavity. If the seed is small, as in sorghums, several are tied together with silk, and the larva lives and feeds outside the seed in the silken ball. Life cycles are completed in about a month in warm weather. The larvae remain dormant in winter, prolonging life cycle to six months or more. Mills, bins, or warehouses are cleaned thoroughly, then pests killed by superheating, freezing, or fumigation. A tiny parasitic chalcid wasp is also an effective control.

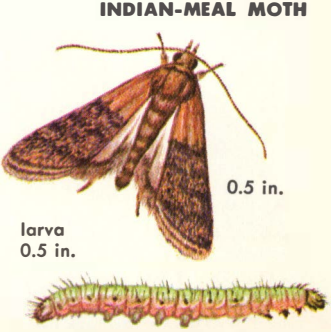
LESSER GRAIN BORERS, pests of stored grains, particularly wheat, are damaging both as larvae and as adults. They also feed on wood and paper. The closely related Larger Grain Borer feeds mainly on corn and is a pest principally in southern United States. Both cold and heat, as used for the Saw-toothed Grain Beetle, are effective, as are fumigants for non-food substances.

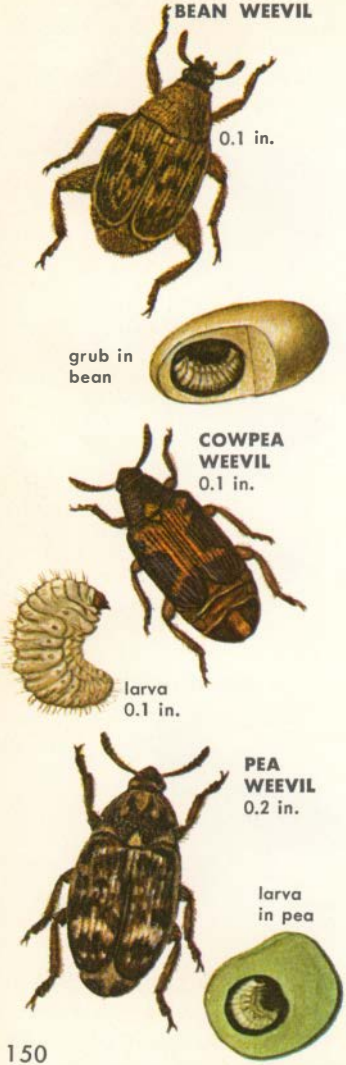


MEDITERRANEAN FLOUR MOTH caterpillars are especially serious pests in flour mills. The caterpillars spin a silken tube in which they live as they feed, and the web masses clog the machinery in the mills. In the home, the caterpillars are found in beans, dried fruits, and many other foods as well as in flour and grain products. As many as six generations may be completed in a year. Destroying the infested food material and cleaning storage areas are best home controls. In mills, pests are killed by fumigation.



INDIAN-MEAL MOTH caterpillars feed on a variety of stored foods, particularly dried fruits and cereals, spinning webs as they feed. In an abundance of food and with proper warmth and moisture a life cycle is completed in a month, with as many as six generations a year. Sanitation and continuous checking to catch infestations early are the best controls in the home. Bins, elevators, or other large storage areas are fumigated.





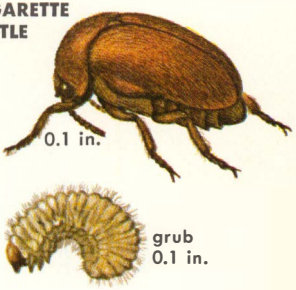
BEAN AND COWPEA WEEVILS eat out the center of stored beans, leaving only the shells. Bean Weevils are found throughout the U.S., the Cowpea Weevil most abundantly in southern states. The grubs, or larvae, hatch from eggs laid in holes chewed into stored beans or into pods in the field. In heavy infestations there may be two dozen or more tiny, newly hatched larvae in one bean. When full grown the larvae form pupae in the eaten-out cavity. As many as six generations are produced in a season. Infested beans should be destroyed. If the beans are to be planted rather than eaten, they should be fumigated first to kill the grubs. The larvae can also be killed by heating the seeds to 145 degrees F. for two hours. Bury vines and pods in the field.

PEA WEEVILS infest only peas. Adult beetles that overwinter in the field feed on the leaves and flowers of the pea plants in the spring. The female beetles lay their eggs on the pea pods, and the spiny larvae burrow inside and begin feeding on a developing seed. The entry hole made by the grub is sealed with silk. The full-grown grub forms a pupa in the seed and in about two weeks emerges as an adult. In cold climates adults may hibernate in stored peas and emerge in the spring. Vines, pods, and other debris should be buried. Plants can be sprayed with a contact insecticide when in bloom to kill adults, or peas can be fumigated at harvesting.

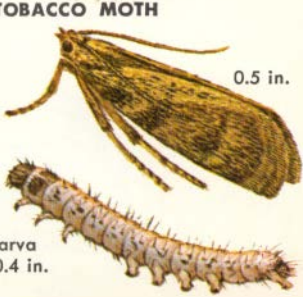
CIGARETTE BEETLE grubs feed on stored tobacco leaves and tobacco products. A life cycle is completed in about 1½ months, with as many as six generations a year. Tobacco warehouses are cleaned and fumigated, or tobacco is exposed to a freezing temperature for a week or longer or heated to 135 degrees F. Beetles also feed on books, spices, upholstered furniture, and seeds. Use fumigants or contact insecticides but do not contaminate foods.

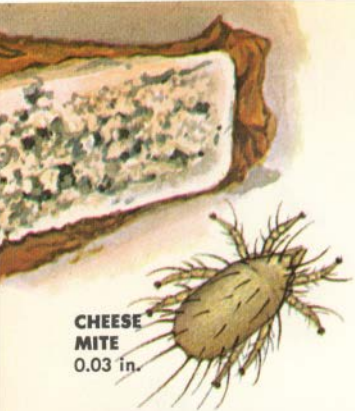
RED-LEGGED HAM BEETLES feed on cured meats, fish, cheese, and other dried foods. Most damage is done by the larvae, which bore into meat, particularly the fat, and collect around the bones. The adults feed at the surface. A life cycle may be completed in as short a time as 30 days. In the home infested foods should be destroyed. Careful cleaning to eliminate bits of food that might support developing larvae is important. The Larder Beetle (p. 31) is also a pest of cured meats.

TOBACCO MOTHS are closely related to Mediterranean Flour Moth and to the Indian-meal Moth but do not infest grains or flour commonly. They are most damaging to stored tobacco, the caterpillars eating holes through the leaves. They are also common pests of stored chocolate and are sometimes referred to as Chocolate Moths. Nuts and other dried foods may be infested too. Control by methods used for Cigarette Beetle.



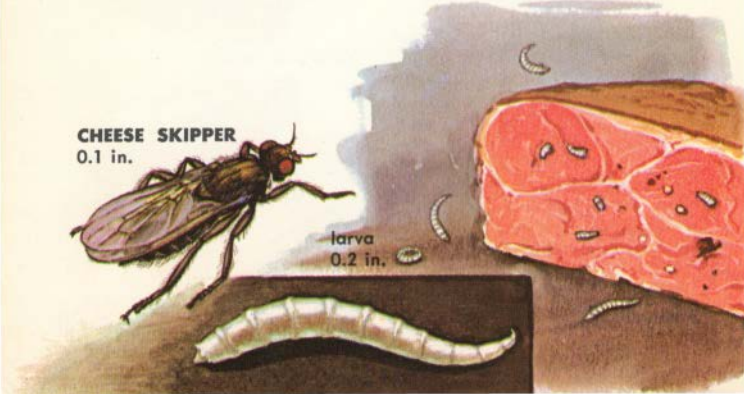




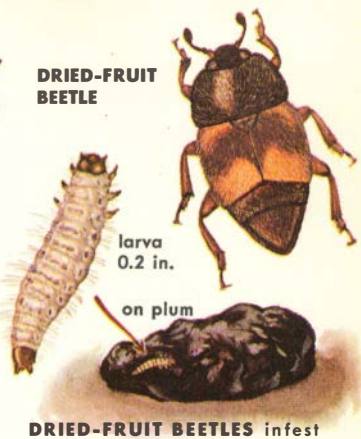


CHEESE MITES and closely related species feed on cheese, cereals, flour, cured meats, and other foods, giving them a sweetish odor. Infested flour appears to seethe, though the mites themselves are nearly microscopic. The shed skins, dead bodies, and excrement form a brownish powder. "Grocer's itch" is a skin irritation produced from handling mite-infested flour. Mites do not thrive in dry conditions; hence do not permit stored food to get damp.

CHEESE SKIPPERS are so named because they sometimes flip into the air to move from one spot to another. To do this the maggot curves its body and holds its tail with the hooks around its mouth, then suddenly releases its hold. Normally the maggots crawl in a wormlike manner. Cheese Skippers infest cured meats as commonly as they do cheeses. When full grown the larvae leave the food and pupate in dark crevices nearby. Adult flies are attracted to the odor of cheese or meat, on which they feed and lay their clusters of eggs. A life cycle requires about 2½ weeks. Infested portions of meat or cheese should be cut off and burned. A fine-mesh screen or cloth over storeroom windows and vents will keep out the adult flies. Where infestations have occurred, fumigation may be necessary. In commercial storage of meats, all stages of the Cheese Skipper can be killed by heating meats to 125 degrees F. for an hour or by storage of meats and cheeses at 43 F. or lower.



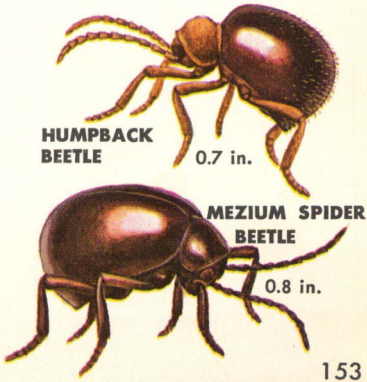




DRUGSTORE BEETLES are common house and storage-area pests. They eat an amazing variety of substances—bread, spices, drugs (including strychnine), and books. They even bore into lead or tinfoil. In cool climates there is one generation per year; in warm climates, four. Burn infested material or expose to about 150 degrees F. for several hours. Fumigation may be necessary in warerooms.

DRIED-FRUIT BEETLES infest both fresh and dried fruits. They are especially serious pests of dates and figs in California, transmitting the spores of fungi and bacteria that cause the fruit to sour. Female beetles lay their eggs on ripe fruit, in which the larvae feed and develop. A life cycle is completed in three weeks in warm weather. Destroy fruit dropped from trees as it will serve as a breeding area.

SPIDER BEETLES feed on dried foods and on feathers, hides, books, drugs, and spices. Unusually resistant to cold, they are active at temperatures as low as 40 degrees F. and are common pests in Canada and northern United States. Many species cannot survive above 80 degrees F. Some, such as the Golden Spider Beetle, are wingless and are spread only by crawling or by man. Clean the infested area and spray with a residual contact insecticide if there is no danger of food contamination.



SCIENTIFIC NAMES

4 *Melanoplus differentialis*
8 *Lepisma saccharina*
9 Chinch: *Blissus leucopterus*
Japanese: *Popillia japonica*
11 Fly: *Winthemia quadripustulata*
Armyworm: *Pseudaletia unipuncta*
Braconid: *Aphidius testaceipes*
Cotton Aphid: *Aphis gossypii*
Cabbage: *Hylemya brassicae*
Rove: *Aleochara bimaculata*
12 Vedalia: *Rodolia cardinalis*
Cottony: *Icerya purchasi*
13 Braconid: *Apanteles glomeratus*
Tobacco: *Protoparce sexta*
Jap. Beetle: *Popillia japonica*
Imported: *Pieris rapae*
15 Tobacco: *Protoparce sexta*
Tarnished: *Lygus lineolaris*
21 Rose Scale: *Aulacaspis rosae*
24 Odorous: *Tapinoma sessile*
Argentine: *Iridomyrmex humilis*
Thief: *Solenopsis molesta*
Pharaoh: *Monomorium pharaonis*
25 Crazy: *Paratrechina longicornis*
Cornfield: *Lasius alienus*
Fire: *Solenopsis xyloni*
Black: *Camponotus pennsylvanicus*
27 E. Sub: *Reticulitermes flavipes*
W. Drywood: *Kalotermes minor*
28 *Blattella germanica*
29 Oriental: *Blatta orientalis*
Brown: *Supella supellectilium*
Amer: *Periplaneta americana*
31 Webbing: *Tineola bisselliella*
Casemaking: *Tinea pellionella*
Plaster: *Tineola walsinghami*
Larder: *Dermestes lardarius*
Carpet: *Anthrenus scrophulariae*
Hide: *Dermestes maculatus*
32 *Musca domestica*
33 Little: *Fannia canicularis*
Green: *Phaenicia* sp.
Blue: *Calliphora vomitoria*
Cluster: *Pollenia rudis*
Moth: *Psychoda alternata*
Fruit: *Drosophila melanogaster*
Eye: *Hippelates collusor*
34 Silverfish: *Lepisma saccharina*
Firebrat: *Thermobia domestica*
Earwig: *Forficula auricularia*
Cricket: *Acheta domesticus*
35 Lyctus: *Lyctus planicollis*
Furniture: *Anobium punctatum*
Book: *Liposcelis divinatorius*
Box: *Leptocoris trivittatus*
Crane: *Tipula abdominalis*
Springtail: *Sira buski*
36 House: *Scutigera coleoptrata*
Millipede: *Parajulus impressus*
Sowbug: *Porcellio laevis*
Pillbug: *Armadillidium vulgare*
Scorpion: *Centruroides gertschi*
37 Daddylonglegs: *Liobunum vittatum*
House: *Achaearanea tepidariorum*
Jumping: *Phidippus audax*
Widow: *Latrodectus mactans*
38 Horse: *Tabanus atratus*
Deer: *Chrysops vittatus*
39 Black Fly: *Simulium venustum*
Sand: *Culicoides canithorax*
Stable: *Stomoxys calcitrans*
41 Mal: *Anopheles quadrimaculatus*
Yellow-fever: *Aedes aegypti*
Salt-marsh: *A. sollicitans*
House: *Culex pipiens*
42 Bed Bug: *Cimex lectularius*
Swallow: *Oeciacus vicarius*
Swift: *Cimexopsis nyctalis*
43 Head: *Pediculus h. capitis*
Body: *P. humanus*
Crab: *Phthirus pubis*
44 Hunter: *Reduvius personatus*
Conenose: *Triatoma sanguisuga*
45 Itch: *Sarcoptes scabiei*
Chig: *Eutrombicula alfreddugesi*
46 Rky. Mt: *Dermacentor andersoni*
Star: *Amblyomma americanum*
Dog: *Rhipicephalus sanguineus*
47 Puss: *Megalopyge opercularis*
Hag: *Phobetron pithecium*
Saddleback: *Sibine stimulea*
Bald-faced: *Vespula maculata*
Paper-nest: *Polistes* spp.
Mud: *Sceliphron cementarius*
48 *Dermacentor variabilis*
49 Cattle: *Boophilus annulatus*
Ear: *Otobius megnini*
Fowl: *Argas persicus*
50 Cat: *Ctenocephalides felis*
Human: *Pulex irritans*
Rat: *Xenopsylla cheopis*
51 Stick: *Echidnophaga gallinacea*
Chigoe: *Tunga penetrans*
52 Head: *Cuclotogaster heterographus*
Body: *Menacanthus stramineus*
53 Sheep: *Bovicola ovis*
Horse: *B. equi*
Hog: *Haematopinus suis*
Cattle: *H. eurysternus*
54 Scab: *Psoroptes equi*
Itch: *Sarcoptes scabiei*
Ear Mange: *Otodectes cynotis*

55 Chicken: *Dermanyssus gallinae*
Scaly: *Knemidokoptes mutans*
Depluming: *K. gallinae*
Hog: *Demodex phylloides*
56 Striped: *Tabanus lineola*
Face: *Musca autumnalis*
57 Horse: *Gasterophilus intestinalis*
Nose Bot: *G. haemorrhoidalis*
Sheep Bot: *Oestrus ovis*
58 *Hypoderma lineatum*
59 N. Cattle: *Hypoderma bovis*
Horn: *Haematobia irritans*
60 Screw: *Callitroga hominivorax*
Sheep Ked: *Melophagus ovinus*
Black Blow: *Phormia regina*
61 *Gryllotalpa hexadactyla*
62 Potato Flea: *Epitrix cucumeris*
Eggplant: *E. fuscula*
Sweet: *Chaetocnema confinis*
Striped: *Phyllotreta striolata*
Pale: *Systena blanda*
Strawberry: *Altica ignita*
Spinach: *Disonycha xanthomelas*
63 Gulf: *Conoderus amplicollis*
Pacific: *Limonius canus*
E. Field: *L. agonus*
64 Variegated: *Peridroma saucia*
Black: *Agrotis ipsilon*
Spotted: *Amathes c-nigrum*
Pale: *Agrotis orthogonia*
65 May: *Phyllophaga rugosa*
Asiatic: *Autoserica castanea*
67 Pea: *Acyrthosiphon pisum*
Bean: *Aphis fabae*
Cabbage: *Brevicoryne brassicae*
Melon: *Aphis gossypii*
68 *Circulifer tenellus*
69 Potato: *Empoasca fabae*
Six: *Macrosteles fascifrons*
S. Garden: *Empoasca solana*
70 Harl: *Murgantia histrionica*
Green: *Acrosternum hilare*
Southern: *Nezara viridula*
71 Tarnished: *Lygus lineolaris*
Squash: *Anasa tristis*
72 Eggplant: *Gargaphia solani*
Onion: *Thrips tabaci*
73 Argus: *Chelymorpha cassidea*
Jamaica: *Eurypepla jamaicensis*
75 Col: *Leptinotarsa decemlineata*
Striped: *Epicauta vittata*
Gray: *E. cinerea*
Spotted: *E. maculata*
Margined: *E. pestifera*
76 Bean: *Cerotoma trifurcata*
Mex: *Epilachna varivestis*
77 Spotted: *Diabrotica undecimpunctata howardi*
Striped: *Acalymma vittata*
78 Vegetable: *Listroderes costirostris obliquus*
Pepper: *Anthonomus eugenii*

78 (cont.)
Sweetpotato: *Cylas formicarius elegantulus*
79 White: *Graphognathus leucoloma*
Car: *Listronotus oregonensis*
Straw.: *Brachyrhinus ovatus*
80 Cabbageworm: *Pieris rapae*
Cab. Looper: *Trichoplusia ni*
Moth: *Plutella maculipennis*
81 Squash: *Melittia cucurbitae*
Pickle: *Diaphania nitidalis*
Melonworm: *D. hyalinata*
82 Potato: *Gnorimoschema operculella*
Beet: *Loxostege sticticalis*
Garden: *L. similalis*
Toma: *Protoparce quinquemaculata*
83 Celery Leaf: *Udea rubigalis*
Celeryworm: *Papilio polyxenes asterius*
Banded Woolly: *Isia isabella*
84 Cabbage: *Hylemya brassicae*
Carrot: *Psila rosae*
Spinach: *Pegomya hyoscyami*
Onion: *Hylemya antiqua*
85 Tomato: *Vasates lycopersici*
Spider: *Tetranychus telarius*
Brown Garden: *Helix aspersa*
Spotted: *Limax maximus*
87 Long: *Pseudococcus adonidum*
Mexican: *Phenacoccus gossypii*
Fern: *Pinnaspis aspidistrae*
Cactus: *Diaspis echinocacti*
Hemi: *Saissetia hemisphaerica*
Brown Soft: *Coccus hesperidum*
Greenhouse: *Orthezia insignis*
88 Greenhouse: *Trialeurodes vaporariorum*
Corn: *Anuraphis maidiradicis*
Chrys: *Macrosiphoniella sanborni*
89 Banded: *Hercinothrips femoralis*
Greenhouse: *Heliothrips haemorrhoidalis*
Glad: *Taeniothrips simplex*
Buff: *Stictocephala bubalus*
90 Chrys: *Corythucha marmorata*
Azalea: *Stephanitis pyrioides*
Cyc: *Steneotarsonemus pallidus*
Bulb: *Rhizoglyphus echinopus*
91 Lesser: *Eumerus tuberculatus*
Narcissus: *Lampetia equestris*
Chrys: *Diarthronomyia chrysanthemi*
Rose: *Dasyneura rhodophaga*
92 Azalea: *Gracilaria azaleella*
Arbor: *Argyresthia thuiella*
Colum: *Phytomyza minuscula*
Larkspur: *P. delphiniae*
93 Colum: *Papaipema purpurifascia*
Lilac: *Podosesia syringae*

93 (cont.)
Oblique: *Archips rosaceanus*
Red: *Argyrotaenia velutinana*

94 Texas: *Atta texana*
Leaf: *Megachile latimanus*
Morn: *Loxostege obliteralis*
Bag: *Thyridopteryx ephemeraeformis*

95 Violet: *Ametastegia pallipes*
Bristly: *Cladius isomerus*
Rose: *Endelomyia aethiops*
Curled: *Allantus cinctus*

96 Black: *Epicauta pennsylvanica*
Rose: *Nodonota puncticollis*
Rose Chafer: *Macrodactylus subspinosus*

97 Fuller: *Pantomorus godmani*
Black: *Brachyrhinus sulcatus*
Rose: *Rhynchites bicolor*

99 Two: *Melanoplus bivittatus*
Differ: *M. differentialis*
Clear-wing: *Camnula pellucida*
Migra: *M. sanguinipes*
Red-legged: *M. femurrubrum*

100 Para: *Lysiphlebus testaceipes*
Greenbug: *Toxoptera graminum*
Aphid: *Anuraphis maidiradicis*
Cornfield: *Lasius alienus*

101 Mead: *Philaenus leucophthalmus*
Legume: *Lygus hesperus*

102 Chinch: *Blissus leucopterus*
Cereal: *Oulema melanopa*

103 Southern Corn: *Diabrotica undecimpunctata howardi*
N. Corn: *D. longicornis*
Grape: *Maecolaspis flavida*

104 Corn: *Chaetocnema pulicaria*
Toothed: *C. denticulata*
Oriental: *Anomala orientalis*
Wheat: *Agriotes mancus*
Plains: *Eleodes opaca*

105 Alfalfa: *Hypera postica*
Maize: *Sphenophorus maidis*
Bluegrass: *S. parvulus*
Curlewbug: *Calendra callosa*

106 Clover Leaf: *Hypera punctata*
Sweet: *Sitona cylindricollis*
Clover Root: *S. hispidula*

107 Lesser: *Hypera nigrirostris*
Boll: *Anthonomus grandis*

108 Cotton: *Alabama argillacea*
Pink: *Pectinophora gossypiella*

109 *Heliothis zea*

110 Army: *Pseudaletia unipuncta*
Fall: *Laphygma frugiperda*

112 *Pyrausta nubilalis*

113 Tobacco: *Protoparce sexta*

114 Stalk: *Papaipema nebris*
S. Corn: *Diatraea crambidoides*
Lesser: *Elasmopalpus lignosellus*

115 Corn: *Crambus caliginosellus*
Alfalfa: *Colias eurytheme*
Clov: *Grapholitha interstinctana*

116 Clover: *Dasyneura leguminicola*
Wheat: *Meromyza americana*

117 *Phytophaga destructor*

118 Wheat Stem: *Cephus cinctus*
W. Joint: *Harmolita tritici*

119 Wheat: *Harmolita grandis*
Clover: *Bruchophagus gibbus*
Thief: *Solenopsis molesta*

120 *Carpocapsa pomonella*

121 Fall: *Alsophila pometaria*
Spring: *Paleacrita vernata*
Eye: *Spilonota ocellana*

122 Peach: *Sanninoidea exitiosa*
Lesser: *Synanthedon pictipes*

123 Peach: *Anarsia lineatella*
Oriental: *Grapholitha molesta*

124 Green: *Lithophane antennata*
Cherry: *Grapholitha packardi*
Fruit: *Archips argyrospilus*

125 *Conotrachelus nenuphar*

126 Apple: *Tachypterellus quadrigibbus*
Flea: *Rhynchaenus pallicornis*
Imbric: *Epicaerus imbricatus*

127 Roundheaded: *Saperda candida*
Flat: *Chrysobothris femorata*

128 Shot: *Scolytus rugulosus*
Peach: *Phloeotribus liminaris*

129 Sinuate: *Agrilus sinuatus*
Japanese: *Popillia japonica*

130 Cherry: *Rhagoletis cingulata*
Apple: *R. pomonella*
Med. Fruit: *Ceratitis capitata*

131 Imported: *Nematus ribesii*
Pear-slug: *Caliroa cerasi*
Woolly: *Eriosoma lanigerum*

132 Apple Aphid: *Aphis pomi*
Spirea: *A. spiraecola*
Rosy: *Anuraphis rosea*

133 Purple: *Lepidosaphes beckii*
Calif: *Aonidiella aurantii*

134 San Jose: *Aspidiotus perniciosus*
Black: *Saissetia oleae*

135 Cottony: *Icerya purchasi*
Vedalia: *Rodolia cardinalis*
Citrus: *Pseudococcus citri*
Citrophilus: *P. gahani*

136 *Dialeurodes citri*

137 Snowy: *Oecanthus niveus*
Citrus: *Scirtothrips citri*

138 Citrus Red: *Panonychus citri*
Citrus Bud: *Aceria sheldoni*
Rust: *Phyllocoptruta oleivora*

139 Eur: *Scolytus multistriatus*
Elm Leaf: *Galerucella luteola*

140 Bronze: *Agrilus anxius*
Poplar: *Saperda calcarata*
Locust: *Megacyllene robiniae*

141 Engel: *Dendroctonus engelmanni*

141 (cont.)
Hick: *Scolytus quadrispinosus*
142 Spruce: *Choristoneura fumiferana*
Gypsy: *Porthetria dispar*
143 *Forest: Malacosoma disstria*
Eastern: *M. americanum*
White: *Hemerocampa leucostigma*
Brown: *Nygmia phaeorrhoea*
144 Carpen: *Prionoxystus robiniae*
Pecan: *Coleophora caryaefoliella*
Calif: *Phryganidia californica*
145 Oyster: *Lepidosaphes ulmi*
Pine: *Phenacaspis pinifoliae*
European: *Gossyparia spuria*
Cottony: *Pulvinaria innumerabilis*
Elm: *Cimbex americana*
146 Granary: *Sitophilus granarius*
Rice: *S. oryzae*
147 Dark: *Tenebrio obscurus*

147 (cont.)
Cadelle: *Tenebroides mauritanicus*
Red: *Tribolium castaneum*
Confused: *T. confusum*
148 Saw: *Oryzaephilus surinamensis*
Angoumois: *Sitotroga cerealella*
Chalcid: *Trichogramma minutum*
149 Lesser: *Rhyzopertha dominica*
Med: *Anagasta kühniella*
Indian: *Plodia interpunctella*
150 Bean: *Acanthoscelides obtectus*
Cowpea: *Callosobruchus maculatus*
Pea: *Bruchus pisorum*
151 Cig: *Lasioderma serricorne*
Red: *Necrobia rufipes*
Tobacco: *Ephestia elutella*
152 Mite: *Tyroglyphus longior*
Skipper: *Piophila casei*
153 Drugstore: *Stegobium paniceum*
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MEASURING SCALE (IN 10THS OF AN INCH)

INSECT PESTS

A GOLDEN NATURE GUIDE

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LEARNING OBJECTIVES

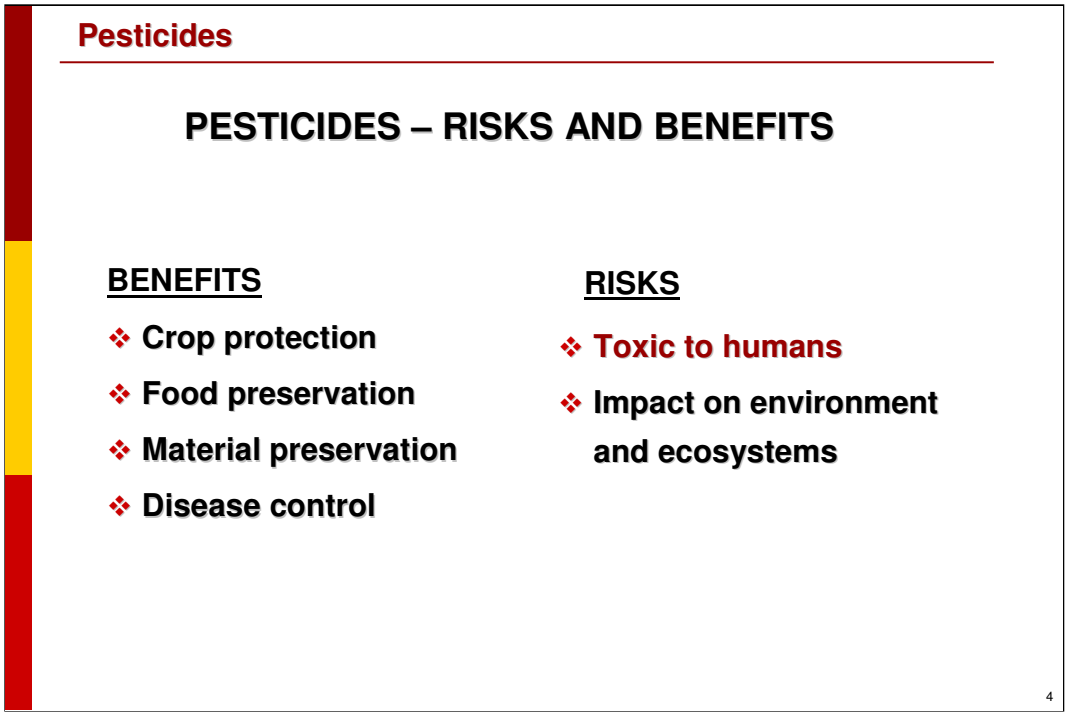
- Learn about pesticides – what they are and what are the risks they may pose?
- Identify the scenarios – where and when are children exposed?
- Recognize signs, symptoms and diseases that may be related to pesticide exposure in children
- Know how to prevent and treat children's pesticide exposure

<<READ SLIDE.>>

OVERVIEW

- What are pesticides?
- Origin, environmental transport and fate of pesticides
- Routes and circumstances of exposure
- Exposure levels
- Toxicokinetics and toxicodynamics
- Target organs and systems
- Diagnosis and treatment of poisoning
- Prevention of pesticide exposure and poisoning

<<READ SLIDE.>>



Pesticides have numerous beneficial effects. These include crop protection, preservation of food and materials and prevention of vector-borne diseases.

For example pesticides may be used in the prevention of malaria, which kills up to 1 million children per year, and for preventing other vector-borne diseases such as dengue, leishmaniasis and Japanese encephalitis.

Pesticides are toxic by design – they are BIOCIDES, designed to kill, reduce or repel insects, weeds, rodents, fungi or other organisms that can threaten public health and the economy.

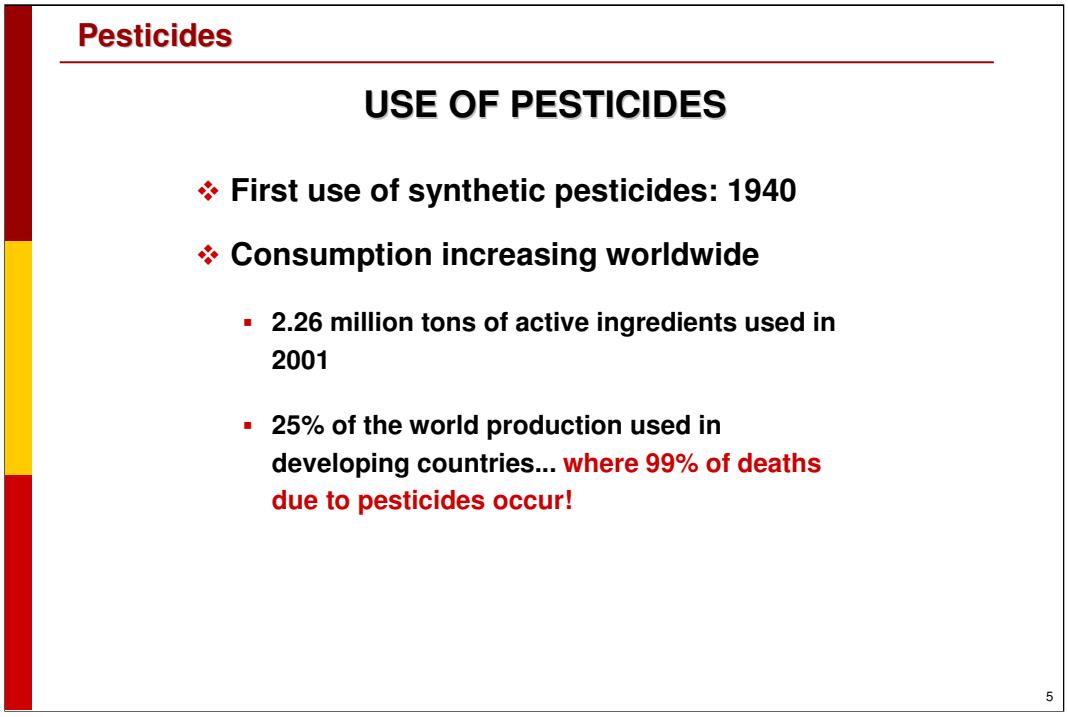
Their mode of action is by targeting systems or enzymes in the pests which may be identical or very similar to systems or enzymes in human beings and therefore, they pose risks to human health and the environment.

Pesticides are ubiquitous in the environment and most are synthetic.

There is growing concern about children's exposure to pesticides and their special susceptibility. Children are not little adults, and may have higher exposures and greater vulnerability at both high and low levels of exposure.

Ref:

•National Resource Council. *Pesticides in the diets of infants and children*. National Academy Press, Washington, DC, 1993.



<<READ SLIDE.>>

a) First use of synthetic pesticides: 1940

b) Consumption increased substantially over time, for example, in the USA, the use of pesticides doubled from 1960 to 1980, but total use has since remained stable or fallen. Most pesticides are used in agriculture, but in 1999 about 74% of households in USA were reported to use at least one pesticide in the home.

c) Use has risen in developing countries and the fastest growing markets in Africa, Asia, South and Central America, Eastern Mediterranean. There is a high pesticide use on crops grown for export (Dr. N. Besbelli, WHO, personal communication).

d) Although developing countries use only 25% of the pesticides produced worldwide, they experience 99% of the deaths. This is because use of pesticides tends to be more intense and unsafe, and regulatory, health and education systems are weaker in developing countries.

Refs:

•American Academy of Pediatrics Committee on Environmental Health. Pesticides. In: Etzel RA ed. *Pediatric Environmental health. 2nd ed.* Elk Grove Village, American Academy of Pediatrics, 2003.

•Jeyaratnam J. Acute pesticide poisoning: a major global health problem. *World Health Stat Quarterly,* 1990.

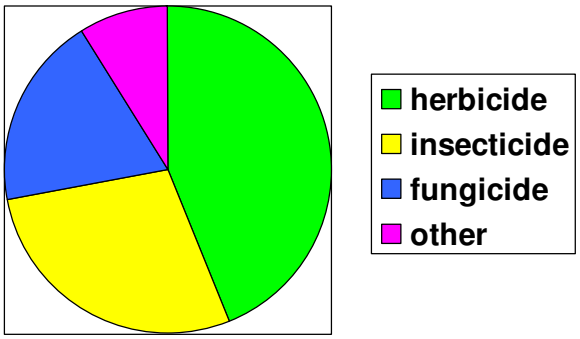
•UNEP United Nations Children´s Fund and WHO. *Children in the new millennium: environmental impact on health.* UNEP, UNICEF, WHO, 2002.

•*US EPA Pesticides industry sales and usage: 2000 & 2001 market estimates:* (www.epa.gov/oppbead1/pestsales/01pestsales/market_estimates2001.pdf).

•Vaagt G. *New code of conduct on pesticide adopted.* FAO Newsroom (www.fao.org/english/newsroom/news/2002/10525-en.html).

USE OF PESTICIDES

Global Pesticide Use 2001 (%)



www.epa.gov/oppbead1/pestsales/01pestsales/market_estimates2001.pdf

The pie chart shows the global use of pesticides and the different types.

Insecticides are mostly used in developing countries and fungicides/herbicides in developed countries.

<<READ SLIDE.>>

Refs:

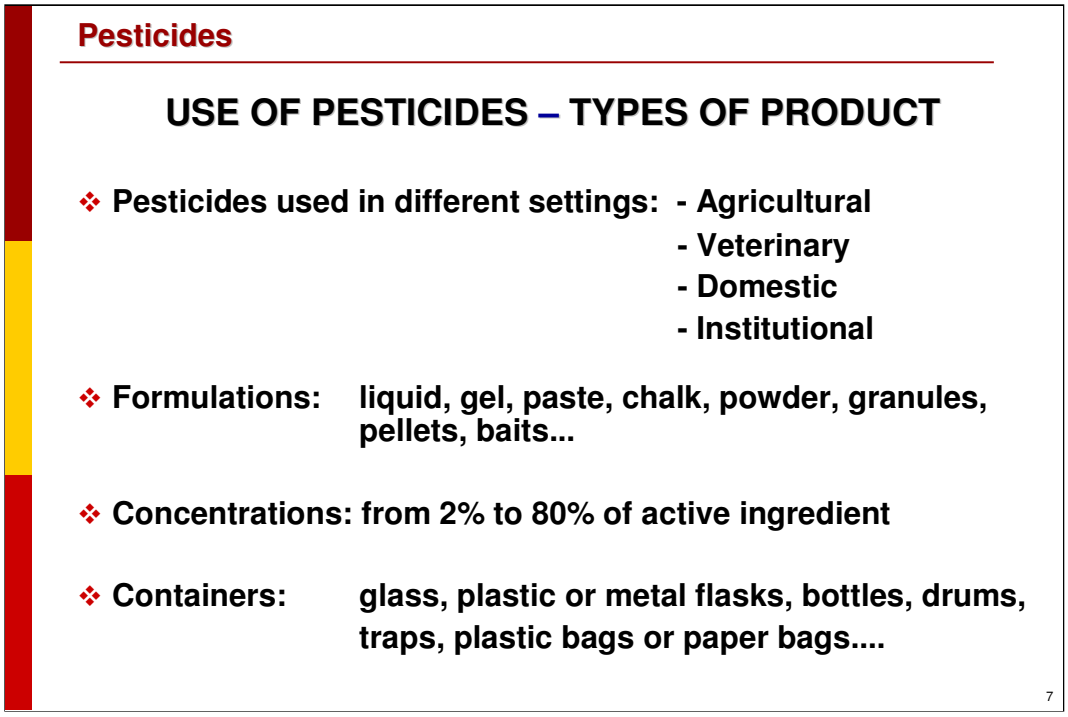
•American Academy of Pediatrics Committee on Environmental Health. Pesticides. In: Etzel RA ed. *Pediatric Environmental health. 2nd ed.* Elk Grove Village, American Academy of Pediatrics, 2003.

•Jeyaratnam. Acute pesticide poisoning: a major global health problem. *World Health Stat Quarterly,* 1990.

•UNEP United Nations Children´s Fund and WHO. *Children in the new millennium: environmental impact on health.* UNEP, UNICEF, WHO, 2002.

•*US EPA Pesticides industry sales and usage: 2000 & 2001 market estimates:* (www.epa.gov/oppbead1/pestsales/01pestsales/market_estimates2001.pdf).

•Vaagt. *New code of conduct on pesticide adopted.* FAO Newsroom (www.fao.org/english/newsroom/news/2002/10525-en.html).



Pesticides are used in different settings.

<<READ SLIDE.>>

•It is important to consider the presentation, concentration and formulation of the products, as the toxic effects depend on the physical state of the product and also on the characteristics of the solvent or other substances contained in the formulation. "Chalk" pesticide has been sold illegally in the USA, it may contain pyrethroids. (See US EPA website.)

•The rate of absorption depends upon the presentation of the product: volatile pesticides and fine powders are more easily inhaled than dense products and coarse granulated materials.

•Concentrated solutions are much more dangerous than diluted ones; solid baits may be colourful, attractive and sweet, and may be easily ingested by toddlers.

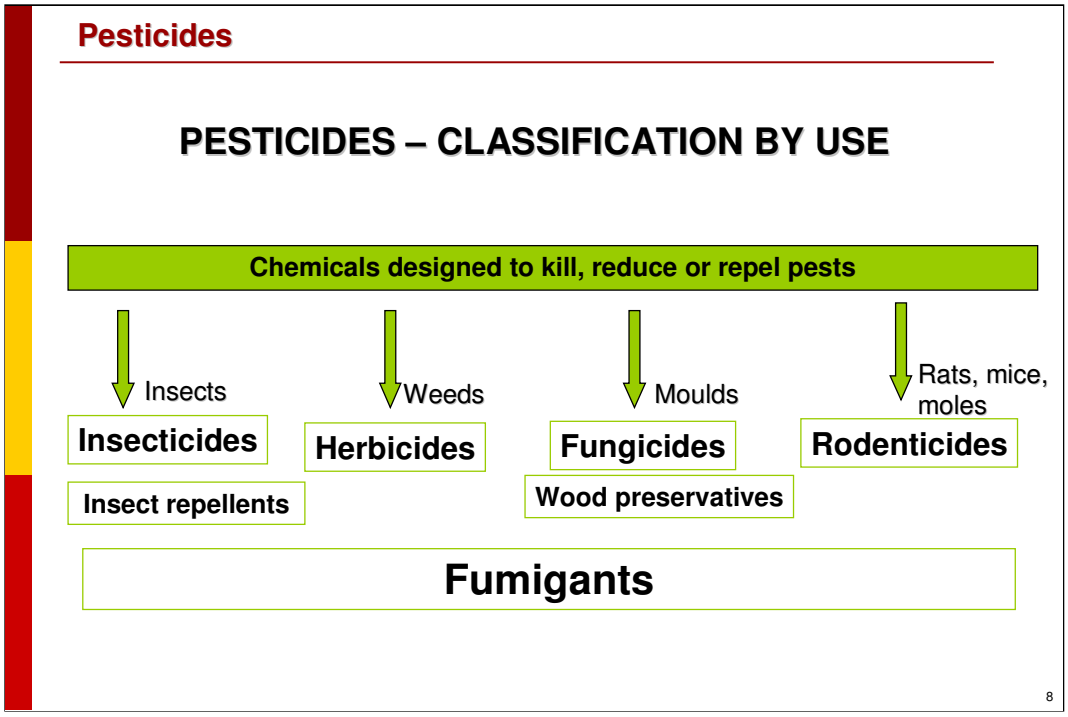
•In some cases, if the concentration of the active compound is less than 2% (as is generally the case for pesticides for household use), the toxicity in cases of human exposure may be due to the solvent (e.g. kerosene or paraffin) and not to the active ingredient.

Refs:

•IPCS. *The WHO Recommended Classification of pesticides by hazard, Guidelines to Classification 2000–2002* (www.inchem.org/documents/pds/pdsother/class.pdf)

•Tomlin C. *The pesticide manual, 11th ed.* British Crop Protection Council Publications, 1997.

•"Chalk" pesticides information at www.epa.gov/opp00001/health/illegalproducts/chalk.htm



There is a large variety of pesticides designed to kill specific pests – those most widely used are listed below.

•**Insecticides** (for killing insects) such as organochlorines, organophosphates and carbamates. This category also includes insect repellents such as diethyltoluamide (DEET) and citronella (of natural origin).

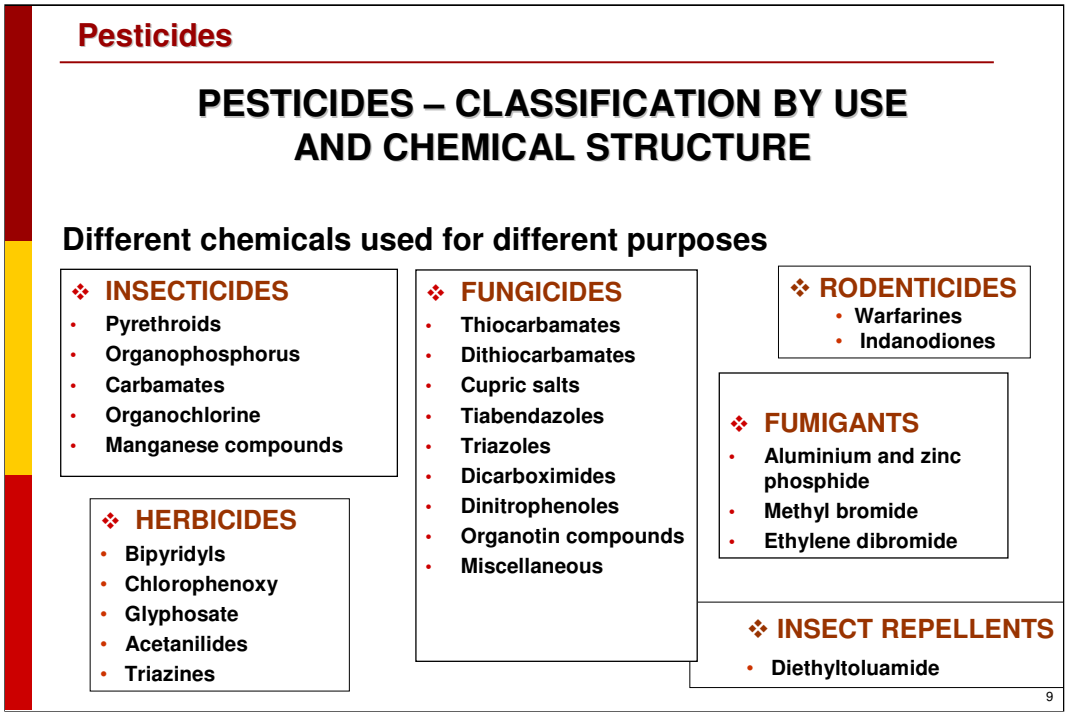
•**Herbicides** or weedkillers (e.g. paraquat, glyphosate and propanil).

•**Fungicides** (to kill mould or fungi): when applied to wood, they are called wood preservatives.

•**Rodenticides** (to kill mice, rats, moles and other rodents).

•**Fumigants** are pesticides that exist as a gas or a vapour at room temperature and may be used as insecticides, fungicides or rodenticides, especially in closed storage places – as they kill every living organism. They are extremely toxic, due to their physical properties, rapid environmental dissemination and human or animal absorption (examples include cyanide, aluminium phosphate and methyl bromide).

•**Other pesticides** include algaecides (to kill algae), miticides (to kill moths) and acaricides (to kill ticks).



There are many groups of chemicals used as pesticides. There are hundreds of different active principles or main ingredients of pesticide groups (e.g. approximately 300 in Uruguay and 900 in the USA).

<<NOTE TO READER: insert the number in your country/region.>>

Some domestic, agricultural or veterinary products may contain more than one chemical belonging to the same or a different chemical group.

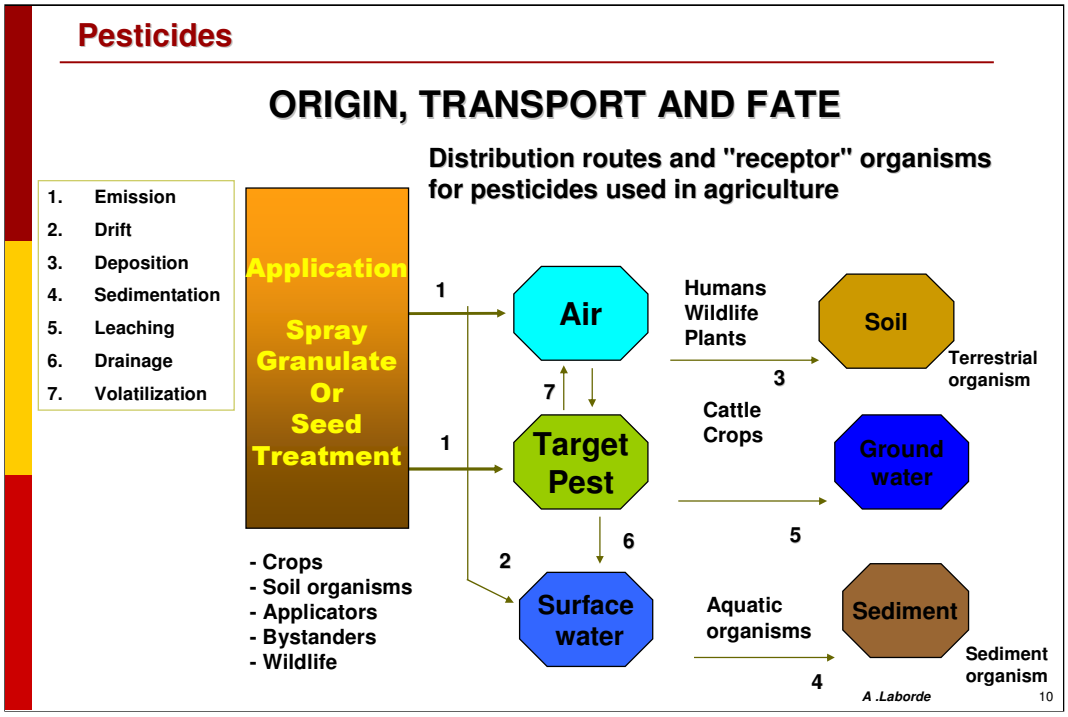
Exposure or emission into the environment can occur from on-site exposure through spraying or application of solid formulations to different targets. For example exposure can occur in children during:

- agricultural use (spraying fields) or seed treatment;
- use in cattle dips and in animal husbandry;
- use as household insecticide (indoor), or in gardens;
- sanitary indoor use in schools, offices, hospitals and other institutions;
- public health use (outdoor or indoor): in parks and urban areas and for vector control (e.g. malaria, Chagas disease, dengue and onchocercasis);
- medical human use: to treat head lice or scabies; and
- veterinary products for pets (e.g. to treat infestations with fleas or ticks).

Refs:

•IPCS. *The WHO recommended classification of pesticides by hazard. Guidelines to Classification 2000-2002* (www.inchem.org/documents/pds/pdsother/class.pdf).

•Tomlin C. *The pesticide Manual, 12th ed.* British Crop Protection Council Publications, 2000.



Pesticides have different distribution and persistence patterns in the environment, even if all of them are distributed in some way through air, soil and water. This should be addressed to gain an understanding of how acute and chronic exposure may occur because air, water and soil are the media of exposure.

This scheme illustrates the routes followed by an agricultural chemical (spray, granulate or seed treatment) that is applied to a given site, representing a risk to applicators, bystanders and wildlife.

When a pesticide is applied directly to a target pest (plant or animal) the whole site is affected including crop plants, soil organisms and, potentially, humans and wildlife in the immediate area. In addition, part of it goes to the air or to surface waters, due to emission (1) or drift (2). Once on the target site, the pesticide may "drain" (6) into surface waters or volatilize (7) into the air. From the air it may deposit (3) on humans, wildlife or plants or on the soil. From the animals or plants where it was applied the pesticide may leak (5) into groundwater.

Pesticides in surface water may go into aquatic organisms, and by sedimentation (4) into other organisms that remain in the sediment.

The persistence of the pesticide depends on its physical and chemical properties (partition coefficients, degradation rates, deposition rates) and the characteristics of the environment.

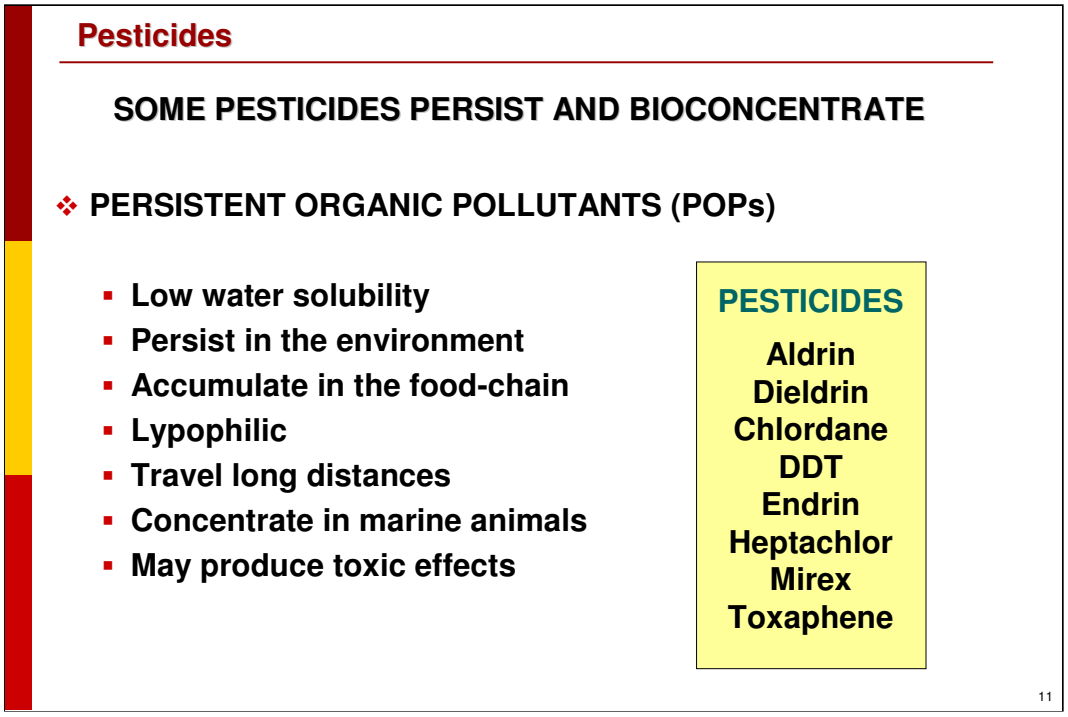
Climate characteristics also play a role in persistence. Studies in the Arctic have shown that insecticides and herbicides persist 3 to 8 times longer in cold climates than in temperate ones.

The most persistent pesticides are termed “persistent organic pollutants” (POPs) and are addressed in a separate module.

Refs:

•*Children: a CICH profile, 3rd ed.* Canadian Institute of Child Health, 2000.

•Health Canada. *Health and the environment: handbook for health professionals.* Ottawa, Ministry of Public Work and Government Services,1998.



Some pesticides are characterized by being very persistent in the environment. They may represent long-term dangers as they biomagnify up the food-chain. Humans, and particularly breastfed babies, are at the top of the food-chain.

•Most POPs (persistent organic pollutants) (these will soon be considered as persistent toxic substances or PTS) are organochlorine pesticides, namely, aldrin, endrin, clordane, DDT, heptachlor, mirex, toxaphene and hexachlorobenzene.

•They have been banned for agricultural or domestic uses in Europe, North America and many countries of South America in accordance with the Stockholm Convention (ratified in 2004). However, some organochlorine pesticides are still used – e.g. DDT is used to control malaria in some developing countries.

•Other POPs (and PTSs) include industrial chemicals (PCBs, HCB) and unintended byproducts (dibenzodioxins, dibenzofurans), and other chemicals.

•These persistent chemicals are controlled under the Stockholm Convention.

•POPs and PTSs are typically lypophilic compounds, with low water solubility, that are resistant to environmental breakdown and accumulate in adipose tissue.

•They bio-concentrate in fish, wildlife and human tissues.

•The highest levels are found in marine mammals.

•There is concern about potential endocrine and developmental effects of the POPs and PTSs, especially in children.

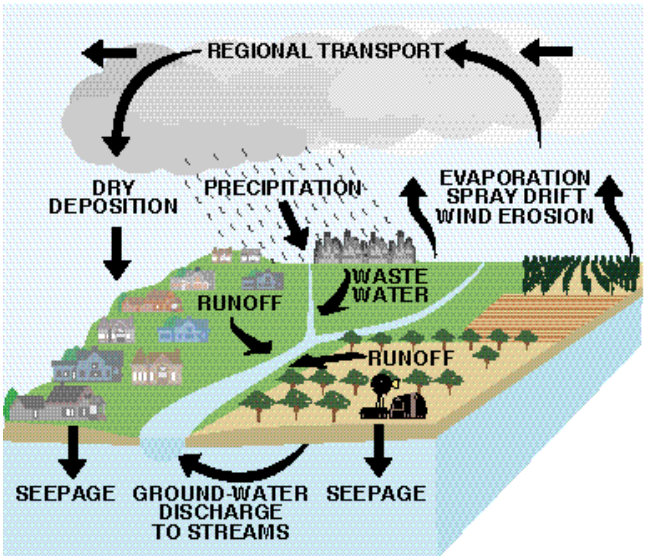
Ref:

•Kutz FW et al. Organochlorine pesticides and polychlorinated biphenyls in human adipose tissue. *Rev Environ Contam Toxicol ,* 1991, 120:1.

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Pesticides

PESTICIDES IN THE ATMOSPHERE AND WATER



USGS

12

The US Geological Survey (USGS) monitors ground and surface water for 76 pesticides and seven pesticide breakdown products. A recent survey found that 90% of streams and 50% of wells tested were positive for at least one pesticide.

Ref:

•USGS: ca.water.usgs.gov/pnsp/index.html

A great potential for adverse effects of pesticides is through contamination of the hydrological system, which supports human life, aquatic life and related food-chains.

Ref:

•USGS: ca.water.usgs.gov/pnsp/atmos/atmos_1.html

Pesticides

EXAMPLE OF SEASONAL PESTICIDE USE

APPLE ORCHARD CALENDAR



NPS

AUTUMN

- **Herbicides: simazine, paraquat, 2-4D**

WINTER

- **Fungicides: dinitroorthocresol (DNOC)**
- **Insecticides: organophosphate compounds (OPs)**

SPRING

- **Fungicides: Cu salts, dithiocarbamates**
- **Insecticides: endosulfan, OPs**

SUMMER

- **Insecticides: OPs**

Ref: Dr A. Laborde, Uruguay

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<<NOTE TO USER: Include your local calendar for pesticide treatment of APPLES or any other agricultural tasks.>>

<<NOTE TO USER: How many pesticides may be found in an apple? Will "Snow-White" be offered a poisoned apple?>>

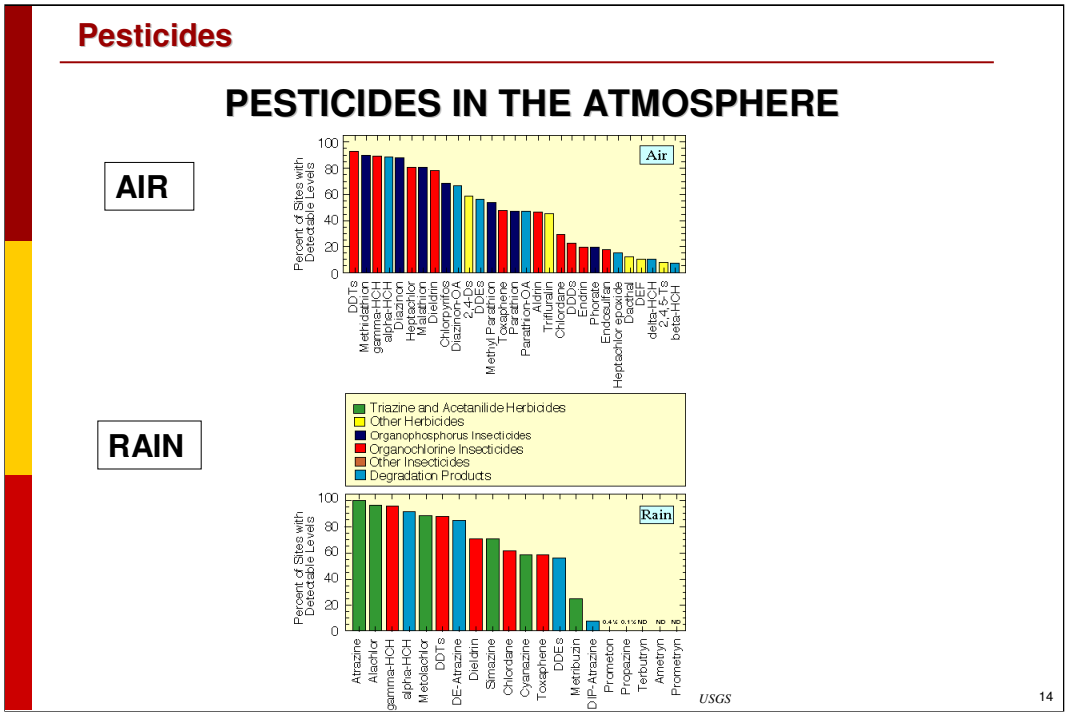
More than 10 different chemicals may be sprayed on apple trees or other vegetable crops before harvest.

The example of a calendar of pesticide application in apple trees in Uruguay was provided by Dr A. Laborde.

Ref:

•Achard. Fruit growing calendar. *Banco de Seguros del Estado Yearbook.* Uruguay, 1996.

Picture: www.nps.gov/whmi/gallery/grounds016.htm – NPS – Us Department of the Interior. Apple orchard



Detection frequencies for those pesticides that have been analysed in air and rain at 10 or more sites in the United States.

Ref:

•USGS. *Pesticides in the atmosphere*: ca.water.usgs.gov/pnsp/atmos/atmos_4.html

Pesticides

CHILDREN'S EXPOSURE

A cause of concern

- Multiple chemicals
- Multiple sources of exposure
- Multiple routes of exposure
- Multiple effects



WHO

15

Pesticides are considered an important environmental threat to children's health in rural areas. This is because:

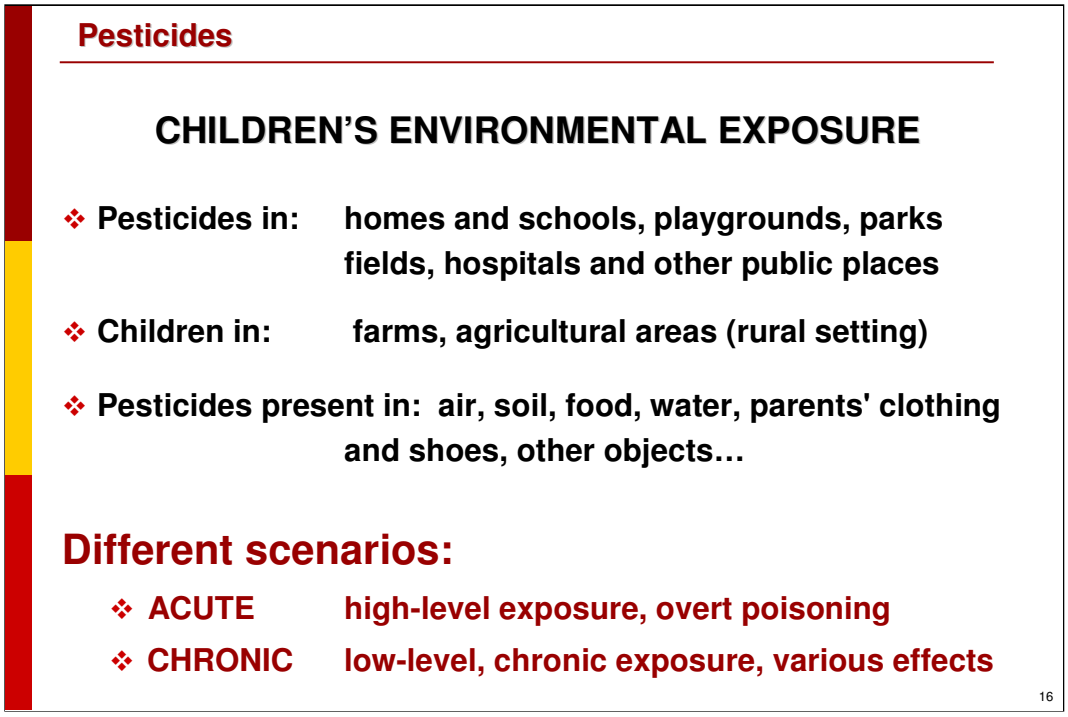
• A large variety of chemicals and mixtures are used as pesticides.

•Many pesticides are used at the same time in the same place (agricultural regions).

•They are ubiquitous in the environment – and in individual environments (micro-environments) of children – there may be several sources of exposure to the same or a different chemical.

•Multiple exposures may occur from the preconception period throughout the child's growth into adolescence and adulthood.

Pesticides may also be heavily used indoors in urban areas, so this is not solely a rural issue.



Children are exposed in different settings and by a variety of routes.

•Pesticides may be unsafely used in the home, by parents who want to protect their children from mosquitoes, cockroaches or rodents. Different pesticides may be stored within the reach of children. They are used in schools and playgrounds (in treated wood) and in green areas (parks and playing fields) to destroy weeds. Hospitals are intended to be places of healing, yet many are using hazardous pesticides

•Living on farms or in agricultural areas, where pesticides are frequently and heavily used, is a high-risk scenario for exposure.

•Potential for "take home" of pesticides on parents' clothing or shoes.

•Pesticides may be present in food and water, either as residues from treatment of crops or at higher levels, as a result of contamination.

•In some areas, there is a potential for release into the environment during production and formulation of pesticides (in factories).

•These are the circumstances under which children may receive **acute and high-level exposure leading to poisoning** or **chronic, low-level exposures** linked to more subtle, developmental and other effects. (See next slide)

Pesticides

SOURCES AND SETTINGS OF EXPOSURE...

HOME, SCHOOL, DAY-CARE, INSTITUTIONS, ...



WHO

Indoor and outdoor application

- Mosquito control
- Professional/domestic application

Health uses

- Lice or scabies
- Fleas or ticks on pets

Pesticide residues

- Dust, soil, furniture, carpets, toys, food…
- Playgrounds, playing fields, lawns, gardens
- Wood preservatives in play structures (e.g. PCP: pentachlorophenol)
- Long range transport of POPs (e.g. DDT)

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A survey by the U.S. Environmental Protection Agency regarding pesticides used in and around the home revealed some significant findings:

•Almost half (47%) of all households with children under the age of five had at least one pesticide stored in an unlocked cabinet, less than 4 feet off the ground (i.e., within the reach of children).

•Approximately 75% of households without children under the age of five also stored pesticides in an unlocked cabinet, less than 4 feet off the ground (i.e., within the reach of children). This number is especially significant because 13% of all pesticide poisoning incidents occur in homes other than the child's home.

Pesticide application

•Professional application of pesticides both indoors and outdoors is used increasingly commonly for the control of rodents, cockroaches, ants, termites, earwigs and other pests. Signs and symptoms of pesticide-related-illnesses have been described after indoor and outdoor spraying.

•Domestic use of insecticides is also a source of exposure. Insecticides formulated as sprays, strips and baits are widely available.

•Certain topical pharmaceuticals for direct application on children's skin or scalp contain insecticides to control lice or scabies. Their use carries a risk of acute (chronic if repeated) overexposure. High doses or applications lasting a long time have caused acute poisoning. There are many pharmaceuticals described in the *International pharmacopoeia* that contain organophosphorus (malathion) and organochlorine (lindane) pesticides still being used to treat head lice. Such products may contains up to 2% of pesticide.

•Dogs and cats are often treated with insecticides to control fleas or ticks. Veterinary products can be as concentrated as agricultural ones. Pet dips for treatment of flea infestations usually contain organophosphate and pyrethroid pesticides. Children are often involved in pet care.

Pesticide residues

•Insecticides may persist in house dust, in soil tracked in from outdoors, in carpets, toys, food and furniture.

•High levels of insecticides have been measured for weeks after professional application.

•Residues of organophosphorus insecticides sprayed in indoor environments have been reported to occur on floors, carpets, children's toys, furniture, bed covers and in dust.

•Poor hygiene habits or houses that are difficult to clean increase the risk of exposure.

•Playgrounds, playing fields, lawns and gardens may be routinely sprayed in order to keep insects away.

•Pesticides are found in recreational waters (lakes, rivers and in pools (algaecides)).

•Persistent wood preservatives such as arsenic/ copper/chromium mixtures have been used on play structures.

•The persistent organic pollutants (POPs) include nine pesticides.

Refs:

•www.epa.gov/pesticides/factsheets/childsaf.htm

•Bass JK et al. What is been used at home: a household pesticide survey. *Rev Panam Salud Publica,* 2001, 9:138.

•*CDC Surveillance for acute insecticide related illness associated with mosquito control efforts Nine States 1999–2002* (www.cdc.gov/mmwr/preview/mmwrhtml/mm5227a1.htm).

•Fields S. Caution – children at play: How dangerous is CCA? *EHP,* 2001, 109 A262 (ehp.niehs.nih.gov/docs/2001/109-6/focus.html)

•Forrester MB et al. Epidemiology of lindane exposures for pediculosis reported to poison centers in Texas, 1998–2002. *J Toxicol - Clin Toxicol,* 2004, 42:55.

•Lemus R et al. Chlorpyrifos: an unwelcome pesticide in our homes. *Rev Environ Health,* 2000, 15:421.

•WHO. *The physical school environment, information series on school health, Document 2.* Geneva, World Health Organization, 2003.

Picture: WHO

Pesticides

Historical use of DDT...



Norsk Barnemuseum

18

Fig: *Norsk Barnemuseum. www.norskbarne.museum.no/html/barn100.htm* Used with copyright permission.

Pesticides

SOURCES AND SETTINGS OF EXPOSURE

Children living on farms or in agricultural areas are exposed to:

- **pesticide drift from sprayed fields**
- **contaminated dust & soil**
- **contaminated equipment and clothes**
- **treated fields**
- **parents spraying**
- **animal dips**
- **child labour**



Corra

19

The rural setting is of particular importance for children and young adults.

Children may be exposed to pesticide drift from fields that are being sprayed.

Acute “unintentional" poisoning, is possible when small children play with pesticide bottles and colourful containers that have been discarded in their playing areas.

Highly concentrated pesticides may be stored in rural homes.

Parents who are farm-workers or applicators may bring pesticides into the home through contaminated clothes, shoes or equipment.

Children may accompany their parents to the fields and help them with their tasks.

Infants who are still being breastfed are often carried by their mothers in the fields.

Children may help with agricultural tasks or may be allowed to play around the sprayed field.

Re-entry intervals (the time required before it is safe to return to a treated area) are not always respected or may be established on the basis of criteria that ensure adult safety only.

Concern is increasing about child labour and young workers.

Although few data are available, it is generally assumed that children make up a substantial part of the agricultural workforce in developing countries. They could be at a higher risk because they are less experienced and assertive than adults; they may lack protective equipment and receive less training or none at all.

Refs:

•Calvert GM et al. Acute pesticide-related illnesses among working youths, 1988-1999. *Am J. Public Health* 2003, 93: 605.

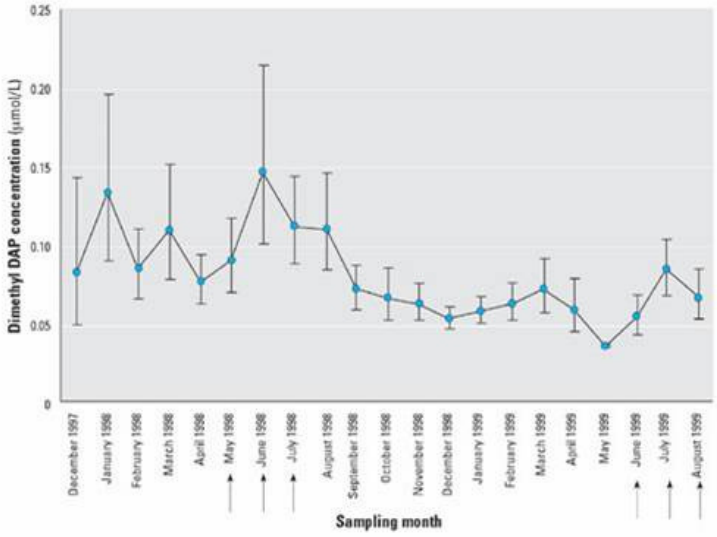
•Quandt SA et al. Agricultural and residential pesticides in wipe samples from farmworker family residences in North Carolina and Virginia. *Environ Health Perspect,* 2004, 112:382.

Picture: L. Corra. Child working with pesticides, Argentina. Used with permission.

Pesticides

CHILDREN'S EXPOSURE IN RURAL SETTINGS

Increase in the levels of organo-phosphorus (OP) metabolites (DAP) paralleling pesticide spraying in a rural area



Koch *EHP*, 2002, 110 (8): 829

20

Numerous studies on children's exposure have demonstrated the absorption of pesticides.

Pesticide metabolites are used as biomarkers of exposure, and children often have higher levels than adults.

Younger children may have higher levels than older ones.

Levels of pesticides were associated with residence in rural areas AND with domestic use of pesticides.

The figure shows levels of dialkylphosphates (DAP) in children living in agricultural areas. Levels were measured in many samples taken over 1 year and were found to increase in parallel with periods of pesticide application.

Refs:

•Aprea C et al. Biologic monitoring of exposure to organophosphorus pesticides in 195 Italian children. *Env Health Perspect* , 2000, 108:521.

•Koch D et al. Temporal association of children's pesticide exposure and agricultural spraying: report of a longitudinal biological monitoring study. *Env Health Perspect,* 2002, 110:829.

We measured organophosphorus (OP) pesticide exposures of young children living in an agricultural community over an entire year and evaluated the impact of agricultural spraying on exposure. We also examined the roles of age, sex, parental occupation, and residential proximity to fields. We recruited 44 children (2–5 years old) through a Women, Infants, and Children clinic. We collected urine samples on a biweekly basis over a 21-month period. Each child provided at least 16 urine samples, and most provided 26. We analysed samples for the dialkylphosphate (DAP) metabolites common to the OP pesticides. DAP concentrations were elevated in months when OP pesticides were sprayed in the region's orchards. The geometric means of dimethyl and diethyl DAPs during spray months were higher than those during nonspray months (p = 0.009 for dimethyl; p = 0.018 for diethyl). Dimethyl DAP geometric means were 0.1 and 0.07 micro mol/L for spray months and nonspray months, respectively (57% difference); diethyl DAP geometric means were 0.49 and 0.35, respectively (40% difference). We also observed differences for sex of the child, with male levels higher than female levels (p = 0.005 for dimethyl; p = 0.046 for diethyl). We observed no differences due to age, parental occupation, or residential proximity to fields. This study reports for the first time the temporal pattern of pesticide exposures over the course of a full year and indicates that pesticide spraying in an agricultural region can increase children's exposure in the absence of parental work contact with pesticides or residential proximity to pesticide-treated farmland.

•Loewenherz C et al. Biological monitoring of organophosphorus pesticide exposure among children of agricultural workers in Central Washington State. *Environ Health Persp* 1997, 105:1344.

Figure: ehp.niehs.nih.gov/members/2002/110p829-833koch/koch-full.html

Reproduced with permission from Environmental Health Perspectives

PESTICIDES IN DIFFERENT MEDIA

Air

- Respirable particles contaminated with pesticides
- Respirable aerosols during spraying
- Vapour from volatile residues of pesticides

Soil

- Hand-to-mouth behaviour
- Crawling on the ground
- Dermal contact

Some pesticides are volatile and can be inhaled over a period of hours or days because of the volatilization from contaminated surfaces.

Particulate material under 10 micrometres is breathable, and the smaller particles are more dangerous because they can reach the alveoli. Children can be exposed when they are around the spraying area.

The persistence of pesticides in the soil depends on their chemical characteristics and many pesticides used in homes have been found, many days to weeks after the application, in house dust.

The behaviour of children (e.g. crawling and hand-to-mouth activities) facilitates exposure.

PESTICIDES IN DIFFERENT MEDIA

Water

- **Pesticides in drinking water: tap, well**

Food

- **Crops routinely sprayed:**
  - **fruits, vegetables, grains**
- **Bioaccumulation in animals and products**
  - **fish, meat, eggs, dairy**



WHO

Once used or spilled, pesticides may contaminate the water used for drinking or bathing.

Pesticides can contaminate nearby groundwater and surface water.

There is increasing concern about dietary ingestion of pesticide residues by children, in both plant and animal products. Please note that the benefits to children of a diet rich in fruits and vegetables should be emphasized. There are preventive and regulatory measures on this issue. (See additional slides)

Picture: WHO, C. Gaggero. Nutrition child, Peru.

<<READ SLIDE.>>

PESTICIDES IN DIFFERENT MEDIA

Food residues

- Many food products have detectable levels of pesticides
- Guideline levels of pesticides in food (MRL)
- Guidelines to limit the population exposure: acceptable daily intake (ADI)



WHO 23

All industrialized countries have food monitoring programmes that measure pesticide residues.

Levels exceeding the maximum established limits have been reported occasionally in monitored food.

Maximum limits for residues have been established only for certain pesticides.

Although a single pesticide may be considered safe at a particular level, foods may contain residues of several pesticides at the same time (see the next slide for an example of the pesticide application scheme in apple trees) and to understand the effect of multiple exposures.

Locally grown food may not be properly monitored or controlled for residues of pesticides.

Families who eat food directly brought in from fields may have higher pesticide exposure.

A study of cumulative dietary pesticide intake in children from an agricultural community showed that up to 56% of the children exceeded the acceptable chronic dietary doses *(Fenske, 2000)*.

Refs:

•American Academy of Pediatrics Committee on Environmental Health. Pesticides. Chapter 24. In: Etzel RA. ed. *Pediatric Environmental Health 2nd Ed.* Elk Grove Village IL, American Academy of Pediatrics, 2003.

•Fenske R et al. Biologically based pesticide dose estimates for children in an agricultural community. *Environ Health Perspect* 2000, 108:515.

•Jensen AF et al. Cumulative Risk assessment of the intake of organophosphorus and carbamate pesticides in the Danish diet. *Food Addit.Contam,* 2003, 20:776.

•Rhorer. Transfer efficiencies of pesticides from household flooring surfaces to food. *J Exp Anal Environ Epidem* 2003, 13:454.

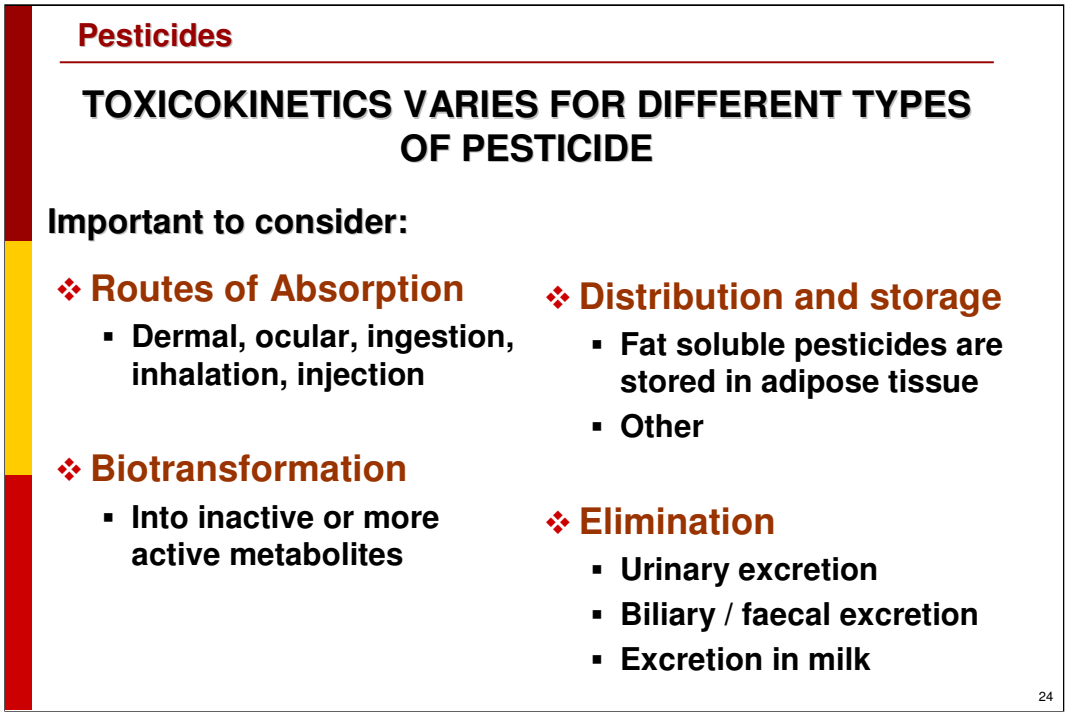
•Sanborn MD et al. Identifying and managing adverse environmental health effects: 4 Pesticides. *CMAJ,* 2002, 166:1431.

•www.who.int/ipcs/food/jmpr/en/

•www.codexalimentarius.net/

•www.who.int/water_sanitation_health/dwq/guidelines/en/

Picture: WHO (L. Taylor), Nutrition, 1994



Toxicokinetics depend on the specific pesticide, its chemical characteristics and formulation.

Routes of absorption are explained in the following slides.

•The biotransformation of most pesticides involves a combination of several chemical reactions including oxidation, reduction, hydrolysis and/or conjugation, producing different metabolites that may be more or less active (toxic).

• Biotransformation of some organophosphate pesticides involves oxidative activation (e.g. parathion = paraoxon).

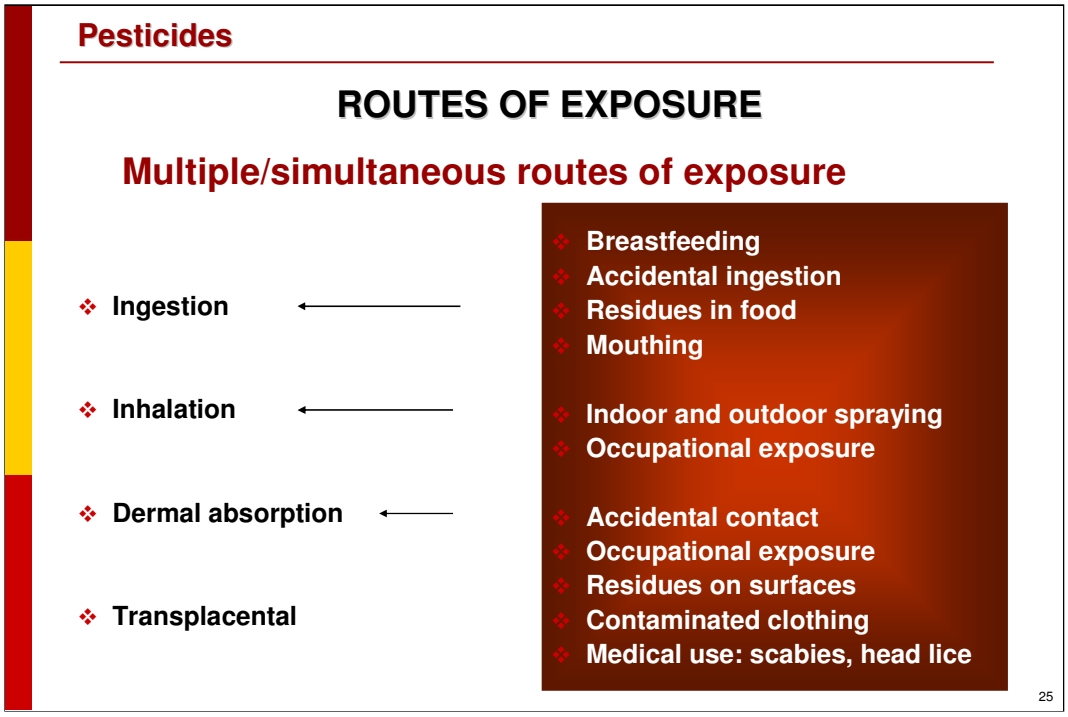
•Pesticides may reach different organs and tissues. Many pesticides accumulate in the adipose tissues.

•Elimination is urinary, biliary and faecal.

•Excretion in milk has been experimentally found to be proportional to blood dosage for DDT, dieldrin, aldrin, heptachlor and other organochlorine pesticides.

Ref:

•Hodgson. Metabolism. In: *Hayes, Handbook of pesticide toxicology*. San Diego California, Academic Press Inc. 1991.



Almost all pesticides are absorbed by these routes.

<<READ SLIDE.>>

Different routes are associated with different settings and media of exposure. However, there are settings in which more than one route of exposure can occur (e.g. in an occupational setting).

Pesticides can cross the epithelium of the skin and mucous membranes that exchange gases (alveoli) or nutrients (gastrointestinal mucosa).

The rate of absorption depends on the chemical properties, amount of the chemical, length of exposure and the physical state of the molecule. There are also other factors that may contribute to increased absorption. Skin absorption is higher when there is vasodilatation (e.g. in summer, or with heating). Respiratory absorption is many times higher when respiration is more rapid (e.g. when playing or running).

(Transplacental exposure is considered in the next slide.)

In relation to their body weight, children have a larger skin area than adults, breathe in more air and drink and eat more. These aspects and certain childhood behaviours such as putting fingers and objects in their mouths allow exposure to larger amounts of pesticide per kilogram of body weight. Modifying diets and assuming their variety could be a way of reducing exposures...

Ref:

•Health Council of the Netherlands. *Pesticides in food: assessing the risk to children.* The Hague: Health Council of the Netherlands, 2004.

Pesticides

ROUTES OF PERINATAL EXPOSURE

- **Mother's intake and body burden is transferred across the placenta**
- **Breast milk may be contaminated**
  "The very top of the food chain"



WHO 26

Pesticides can cross the placenta:

•They have been detected in the amniotic fluid and body tissues of human foetuses even during early stages of prenatal life.

•Pesticides have also been found in the meconium.

•Measuring organophosphate compounds (OP) metabolites in meconium is considered a good biomarker of prenatal exposure because meconium starts to accumulate in the 16th week of pregnancy and is eliminated following delivery.

Breast milk may be contaminated and represents the very top of the food-chain:

•Residues of organochlorine pesticides and POPs have been detected in breast milk (including DDT, HCB and HCH isomers) in contaminated areas.

•There is currently no developed method to measure OPs in breast milk.

(Please see the module on Children and Chemicals.)

Refs:

•Pronczuk J et al. Global perspectives in breast milk contamination infectious and toxic hazards. *Environ Health Perspect,* 2002, 110:A349.

•Whyatt RM et al. Measurement of organophosphate metabolites in postpartum meconium as a potential biomarker of prenatal exposure. A validation study. *Env Health Perspect,* 2001, 109:417.

Picture: WHO, P. Virot. Portrait of a young baby breastfeeding, Delhi, India, Asia, November 2002.

Pesticides

METABOLIC PATHWAYS

- **Organophosphates metabolize into:**
  - **Oxones**
  - **Specific inactive metabolites (ME)**
  - **Non-specific metabolites: dialkylphosphates (DAPs)**

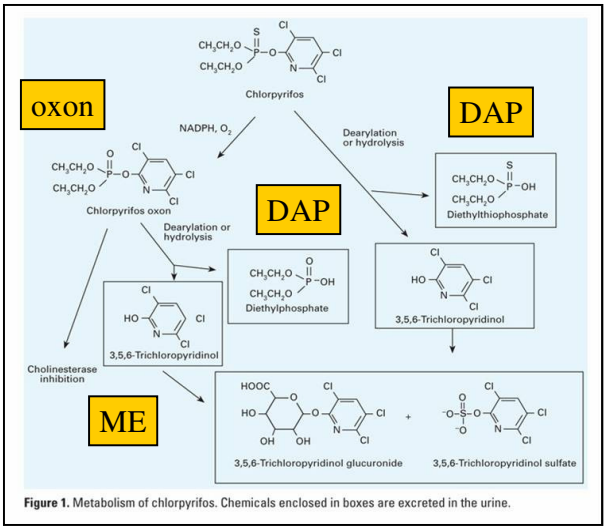


Figure 1. Metabolism of chlorpyrifos. Chemicals enclosed in boxes are excreted in the urine.

Wessels, EHP (2003) 111 (16): 1939

27

Metabolism may either activate or inactivate the chemical.

Therefore, immature metabolic pathways may be protective or increase the danger from specific chemicals.

As an example, organophosphates are metabolized to oxones (active metabolite), but also to other specific inactive metabolites (ME) and to non-specific metabolites (the dialkylphosphates (DAPs)) (shown in the figure).

DAPs are used as biomarkers of environmental exposure to all kinds of organophosphate pesticides because DAPs are metabolites of all these pesticides.

Ref:

•Wessels D et al. Use of biomarkers to indicate exposure of children to organophosphate pesticides: implications for a longitudinal study of children's environmental health. *Environmental Health Perspectives*, 2003, 111:1939.

Figure: Reproduced with permission from Environmental Health Perspectives

MECHANISMS OF ACUTE TOXICITY

- Irritation (most of the pesticides)
- Allergic sensitization (e.g. fungicides)
- Enzyme inhibition (e.g. cholinesterases and OPs & carbamates)
- Oxidative damage (e.g. paraquat)
- Inhibition of neurotransmission (e.g. organochlorines)
  - Calcium (Ca^{2+}) homeostasis alteration
  - GABA inhibition
- Uncoupling of oxidative phosphorylation (e.g. glyphosate)

Several mechanisms of toxicity have been described and these differ according to the specific properties of the pesticide. They are summarized below.

•Irritation is a local effect due to contact of the pesticide with the skin, eyes or other mucosa.

- The effects are usually redness and pain.

- Respiratory irritation can produce nasal, laryngeal or pulmonary effects.

- Most herbicides and fungicides are strong irritants.

•Allergic sensitization is a common effect of pesticides, especially fungicides.

•Enzyme inhibition (e.g. cholinesterase activity is decreased by exposure to organophosphorus compounds and carbamates).

•Oxidative damage (e.g. paraquat is a promoter of superoxide radicals).

•Inhibition of neurotransmission (organochlorines inhibit the GABA system and cause alteration of calcium homeostasis.

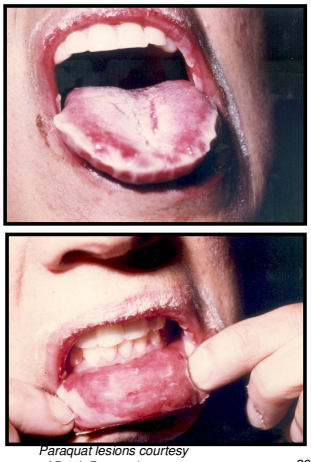
•Uncoupling of oxidative phosphorylation (e.g. glyphosate).

OP: organophosphorus compounds

Pesticides

ACUTE PESTICIDE-RELATED ILLNESS

- Dermal and ocular irritation (or allergic response)
- Upper and lower respiratory tract irritation
- Allergic responses / asthma (fungicides)
- Gastrointestinal symptoms
- Neurological symptoms
- Specific syndromes
  - Cholinergic crisis (organophosphorus pesticides)
  - Bleeding (warfarin-based rodenticides)
  - Caustic lesions and pulmonary fibrosis (herbicide, paraquat)



Paraquat lesions courtesy of Dr. J Pronczuk

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The signs and symptoms of pesticide poisoning depend upon the pesticide involved and the type and magnitude of exposure.

In general the signs and symptoms are:

•dermal and ocular irritation (or allergic response)

•upper and lower respiratory tract irritation

•allergic responses and asthma

•gastrointestinal symptoms: usually vomiting, diarrhoea and abdominal pain

•neurological symptoms: excitatory signs in the case of exposure to organochlorines, lethargy and coma; also polyneuritis

•specific syndromes:

- cholinergic crisis (organophosphorus pesticides)

- bleeding (warfarin-based rodenticides)

- caustic lesions and pulmonary fibrosis (paraquat)

<<NOTE TO USER: Refer to those pesticides commonly used in the country/area.>>

<<NOTE TO USER: insert local photo.>>

<<READ SLIDE.>>

Refs:

•American Academy of Pediatrics Committee on Environmental Health. Pesticides. Chapter 24. In: Etzel RA. ed. *Pediatric Environmental Health, 2nd Ed.* Elk Grove Village Il. American Academy of Pediatrics, 2003.

•CDC. Surveillance for acute insecticide-related illness associated with mosquito-control efforts--nine states, 1999–2002. *MMWR Morb Mortal Wkly Rep,* 2003, 52:629.

•Salameh PR et al. Respiratory symptoms in children and exposure to pesticides. *Eur Respir J* , 2003, 22:507.

•Sanborn MD et al. Identifying and managing adverse effects: 4 Pesticides. *CMAJ,* 2002, 166:1431.

Pictures: Courtesy of Dr. J. Pronczuk. Lesion caused by paraquat.

Pesticides

ACUTE POISONING BY "ACCIDENTAL" INGESTION

- **Storage of leftover pesticide in a medicine or soft drink bottle**
- **Confusion with pharmaceutical**
- **Pesticide container reused for storing drinks or food**
- **Pesticide container present in the child's environment**



Bottles containing pharmaceuticals and the pesticide chlorpyriphos
Laborde, CIAT, Montevideo

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Acute poisoning results from "accidental" (non-intentional) exposure in toddlers and small children.

Ingestion occurs, for example, when:

•Pesticides have been stored in a medicine or soft drink bottle.

•The pesticide bottle is similar to a bottle used for pharmaceuticals.

•Pesticide containers are reused for storing drinks or food.

•Pesticide containers are easily accessible in the child's environment.

Photo: Bottles containing pharmaceuticals and the pesticide chlorpyriphos
Courtesy of Laborde, CIAT, Montevideo

Pesticides

DIAGNOSIS OF EXPOSURE

- **History of exposure**
  - **Availability of pesticides**
  - **Recent application**
- **Signs and symptoms**
  - **May be misdiagnosed!**
- **Laboratory tests**



WHO

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<<READ SLIDE.>>

The diagnosis is based upon the history of exposure (e.g. pesticides are available in the home, recently applied, or child was found playing with containers), signs and symptoms of exposure (see next slides) and laboratory measurements. Diagnosis also requires a high index of suspicion. Even after acute exposures, pesticide poisoning may be misdiagnosed as a viral illness (e.g. infectious diarrhoea rather than organophosphate poisoning) resulting in inadequate treatment and potentially returning children to a setting where exposure will be ongoing or recur.

Pesticides and/or their metabolites can be measured in samples of blood, urine, breast milk, amniotic fluid or meconium. This can confirm the diagnosis.

Laboratory tests are available to assess exposure to organophosphates, organochlorine, dicarboximide fungicides, carbamates, dipyridyl herbicides (e.g. paraquat) and pyrethroids.

Ref:

•American Academy of Pediatrics Committee on Environmental Health. Pesticides. Chapter 24. In: Etzel RA. ed. *Pediatric Environmental Health,* 2nd Ed. Elk Grove Village II. American Academy of Paediatrics, 2003.

Picture: WHO, C. Gaggero. Health child examination, Peru.

Pesticides

ACUTE TOXINDROMES

PESTICIDE	ACUTE SYMPTOMS	DIAGNOSIS	TREATMENT
Organo phosphorous E.g. Clorpyriphos Diazinon Azinphos Parathion	**"Irreversible" cholinesterase inhibition** Cholinergic crisis: - nausea, vomiting - hypersecretion - miosis - fasciculations - coma	**Low cholinesterase levels in red blood cells (RBC)**	- Supportive care - Atropine i/v - Oximes - Decontamination
Carbamates E.g. Carbaryl Aldicarb	**Reversible cholinesterase inhibition**	**Low cholinesterase levels (in RBC)**	- Supportive care - Atropine i/v - Decontamination

32

<<READ SLIDE.>>

Modified from Table of American Academy of Pediatrics, Committee on Environmental Health. In: Etzel, R. ed. *Paediatric Environmental Health 2nd Ed*. Elk Grove Village Il, 2003.

Pesticides

ACUTE TOXINDROMES

PESTICIDE	ACUTE SYMPTOMS	DIAGNOSIS	TREATMENT
Pyrethroids			
Type I E.g. Allethrin Permethrin Tetramethrin	- Tremor - Ataxia - Irritability	- Urinary 3-phenoxybenzoic acid (in research studies)	- Supportive care - Symptomatic - Decontamination
Type II E.g. Deltamethrin Cypermethrin Fenvalerate	- Salivation - Temporary paraesthesias - Seizures	- Urinary 3-phenoxybenzoic acid (in research studies)	- Supportive care - Symptomatic - Decontamination
Organo-chlorines E.g. Lindane Endosulfan	GABA blockade: - Tremors - Dizziness - Seizures	- Detectable in blood	- Supportive care - Symptomatic - Decontamination

33

<<READ SLIDE.>>

Modified from Table of American Academy of Pediatrics. Committee on Environmental Health. In: Etzel ed. *Pediatric Environmental Health, 2nd Ed.* Elk Grove Village Il, 2003.

Ref:

•Aprea C et al. Analytical method for the determination of urinary 3-phenoxybenzoic acid in subjects occupationally exposed to pyrethroid insecticides, *J Chromatogr B Biomed Sci Appl,* 1997, 695:227.

Pesticides

ACUTE PESTICIDE TOXINDROMES

PESTICIDE	ACUTE SYMPTOMS	DIAGNOSIS	TREATMENT
Chlorophenoxy compounds (e.g. 2,4-D)	Nausea, vomiting, acidosis, myalgia fever, myopathy, neuropathy	Detectable in urine and blood	Decontamination and Urine alkalinization
Bipyridyl compounds paraquat	Vomiting Corrosive lesions Hepatotoxicity Acute tubular necrosis Pulmonary fibrosis	Dithionite test in urine	Decontamination Avoid O_2 haemoperfusion Possibly: corticosteroids and cyclophosphamide
Anticoagulant rodenticide Warfarin Brodifacoum Diphacinone	Haemorrhage (from vit. K antagonism)	Elevated prothrombin time (PT)	Vitamin K1 (Fitomenadione)

34

<<READ SLIDE.>>

Modified from Table of American Academy of Pediatrics. Committee on Environmental Health. In: Etzel R. ed. *Pediatric Environmental Health, 2nd Ed.* Elk Grove Village Il, 2003.

Pesticides

LOW-LEVEL CHRONIC EXPOSURE

Growing body of epidemiologic and animal data and research studies suggests a link between long-term exposure and:

- **Abnormal growth and development**
- **Impaired neurobehavioral development / functions**
- **Cancer**
- **Increased susceptibility to infections**

35

The mechanisms of action thought to produce chronic toxic effects include genotoxicity, endocrine disruption and immunotoxicity.

Effects may be seen when exposure occurs during critical windows of development, particularly the prenatal period. See additional slides.

Ref:

•*Children in the New Millennium: Environmental Impact on Health*. UNEP, UNICEF, WHO, 2002.

•Eskenazi B et al, Exposures of children to organophosphate pesticides and their potential adverse health effects. *Environ Health Perspect*, 1999, 107(3):409–419.

Pesticides

PRECONCEPTIONAL PRENATAL EXPOSURE

Pesticide exposure before or during pregnancy has been associated with increased risk of:

- **Infertility**
- **Perinatal death**
- **Spontaneous abortion**
- **Premature birth**
- **Fetal growth retardation**
- **Congenital malformations**
- **Early childhood cancer**



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Exposure of either **mother** or **father** to pesticide before conception, or exposure of the mother during pregnancy, has been associated with an increased risk of fetal death, spontaneous abortion and early childhood cancer.

There is increasing evidence that *in utero* exposure increases the risk of growth retardation: a small-for-gestational age baby, low birth weight, reduced length and small head circumference (see photo).

Significant increases in the risk of congenital anomalies have also been reported. These include**:** eye defects, limb reduction, urogenital defects, hypospadias, cryptorchidism, orofacial clefts, central nervous system defects and heart defects.

Refs:

•Bell EM et al. A case-control study of pesticides and fetal death due to congenital anomalies. *Epidemiology*, 2001, 12:148.

•Berkowitz GS et al. *In utero* pesticide exposure, maternal paraoxonase activity, and head circumference. *Environ Health Perspect*, 2004, 112:388.

•Eskenazi B et al. Association of *in utero* organophosphate pesticide exposure and fetal growth and length of gestation in an agricultural population, *Environ Health Perspectives*, 2004, 112 (10): 1116-1124.

•Garcia AM et al. Parental agricultural work and selected congenital malformations. *Am J Epidemiol* 1999, 149:64.

•Heeren GA et al. Agricultural chemical exposures and birth defects in the Eastern Cape Province, South Africa. A case - control study. *Environ Health*, 2003, 2:11.

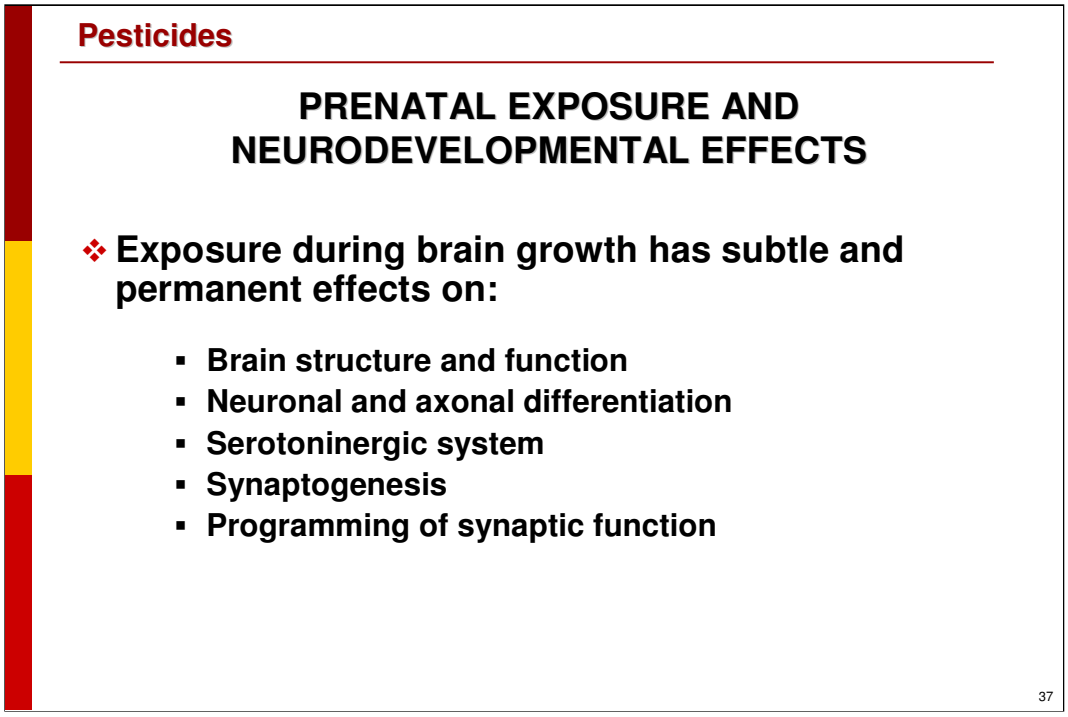
•Nurminen T. Maternal pesticide exposure and pregnancy outcome. *J Occup Environ Med*, 1995, 37:935.

•Rojas A et al. Malformaciones Congenitas y exposicion a pesticidas. *Rev Med Chilena,* 2000, 128:399.

•Schreinemachers DM. Birth malformations and other adverse perinatal outcomes in four U.S. Wheat-producing states. *Environ Health Perspect* , 2003, 111 :1259.

•Weidner IS et al. Cryptorchidism and hypospadias in sons of gardeners and farmers. *Environ Health Perspect*, 1998, 106:793.

•Whyatt RM et al. Prenatal insecticide exposures birth weight and length among an urban minority cohort. *Environ Health Perspect* , 2004, 112:1125.



Exposure during brain growth may exert subtle, permanent effects on the structure and function of the brain. These include:

•neuronal and axonal differentiation;

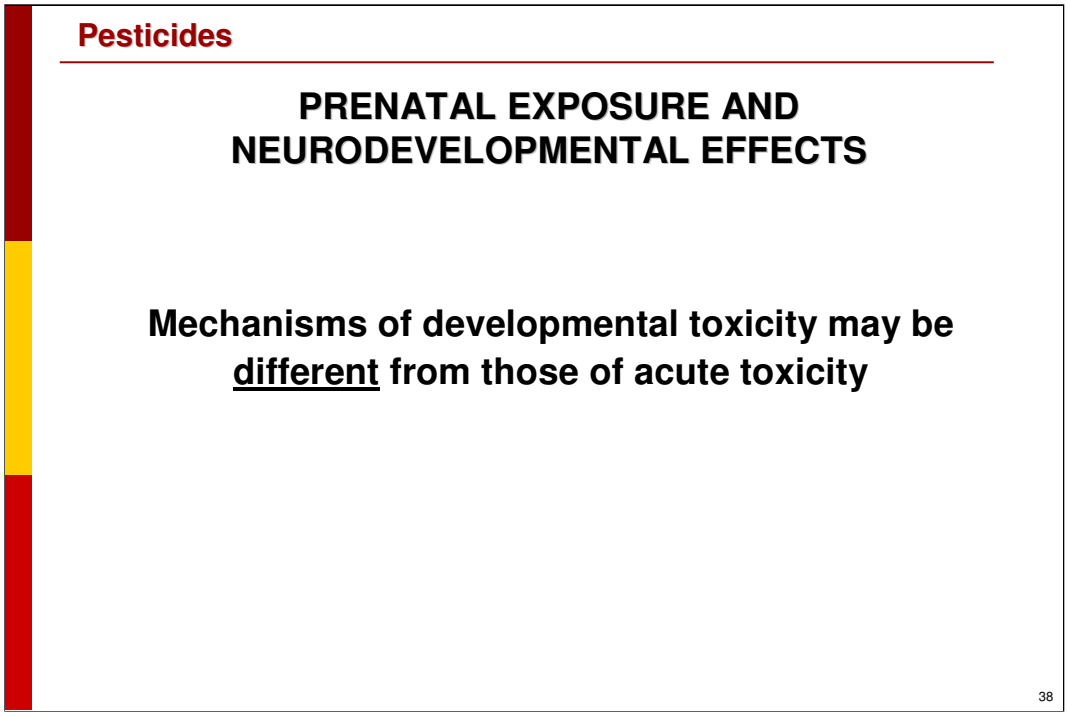
•alteration of serotoninergic system; and

•altered synaptogenesis and programming of synaptic function.

Ref:

•Slotkin TA. Guidelines for developmental neurotoxicity and their impact on organophosphate pesticides: a personal view from an academic perspective, Neurotoxicology, 2004, 25:631.

The appropriate regulation of drugs, chemicals and environmental contaminants requires the establishment of clear and accepted guidelines for developmental neurotoxicity. Ideally, these guidelines should encompass the ability to assess widely disparate classes of compounds through routine tests, with high throughput and low cost. Increasingly, however, the progress in primary research from academic laboratories deviates from this goal, focusing instead on categorizing novel effects of toxicants, development of new testing paradigms, and extension of techniques into molecular biology. The differing objectives of academic science as opposed to those of regulatory agencies or industry, are driven in part, by the priorities of the agencies that fund primary research. Recent work on organophosphate pesticides (OPs) such as chlorpyrifos (CPF) illustrate this dichotomy. Originally, OPs were thought to affect brain development through their ability to elicit cholinesterase inhibition and consequent cholinergic hyperstimulation. This common mechanism allowed for parallels to be drawn between standard measures of systemic toxicity, gross morphological examinations, and exposure testing utilizing an easily-assessed surrogate end-point, plasma cholinesterase activity. In the past decade, however, it has become increasingly evident that CPF, and probably other OPs, have direct effects on cellular processes that are unique to brain development, and that these effects are mechanistically unrelated to inhibition of cholinesterase. The identification and pursuit of these mechanisms and their consequences for brain development represent new and exciting scientific findings, while at the same obscuring the ability to sustain a uniform approach to neurotoxicity guidelines or biomarkers of exposure. In the future, a new set of test paradigms, relying on primary work in cell culture, invertebrates, or non-mammalian models, followed by more targeted examinations of specific processes in mammalian models, may unite cutting-edge academic research with the need for establishing flexible guidelines for developmental neurotoxicity.



Acetylcholinesterases are enzymes that play a direct role in axonal outgrowth and neuronal differentiation. Exposure to organophosphorus pesticides inhibits the enzymes and may therefore interfere with this function. The pesticides chlorpyrifos and diazinon alter axonogenesis, synaptogenesis and programming of synaptic functions. The mechanisms of action postulated are: serotonergic system alteration and inhibition of RNA synthesis in neurones and glial cells. Data suggest that some of the toxicity is from the parent compound rather than the active metabolite and occurs independently of the cholinergic systems that are responsible for acute toxicity.

And, these neurodevelopmental toxicities occur at exposure levels too low to cause overt symptoms of cholinesterase inhibition in the pregnant animals.

Refs:

•Aldridge JE et al. Serotonergic systems targeted by developmental exposure to chlorpyrifos: effects during critical periods. *Environ Health Perspect,* 2003, 111:1736.

•Colosio C et al. Neurobehavioral effects of pesticides. State of the art. *Neurotoxicology,* 2003, 24:577.

Pesticides

CHRONIC NEUROLOGICAL EFFECTS

- **Neurological sequelae of acute poisoning**
- **Neurological symptoms due to high indoor levels of pesticides**
- **Subtle changes in memory and attention**

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It may be difficult to differentiate the effects of prenatal exposure from exposure in early childhood, or sequelae of non-fatal acute poisonings.

Chronic neurobehavioural and neurological effects after acute poisoning with organophosphorus pesticides have been reported in adults.

Memory and concentration problems, unusual fatigue, irritability and depression, visual difficulties and delayed polyneuropathy have been described.

In a well-documented case of chronic organophosphorus pesticide poisoning, the house of an infant with hypertonia, first diagnosed as cerebral palsy, was found to have high levels of chlorpyrifos weeks after a professional application (*Wagner, 1994*).

Few studies have examined the neurobehavioural effects of postnatal exposure to pesticides.

Subtle changes in short-term memory and attention may be associated with application of organophosphorus pesticides in the home.

There is increasing evidence, particularly from animal models, about neurobehavioural effects of long-term exposure to low levels of pesticides.

Refs:

•American Academy of Pediatrics Committee on Environmental Health. Pesticides. Chapter 24. In: Etzel R. ed. *Pediatric Environmental Health 2nd Ed* Elk Grove Village Il, American Academy of Pediatrics, 2003.

•Eskenazi B et al, Exposures of children to organophosphate pesticides and their potential adverse health effects. *Environ Health Perspect*, 1999, 107(3):409–419.

•Keifer M et al. Symptoms and cholinesterase activity among rural residents living near cotton fields in Nicaragua. *Occup Environ Med*, 1996, 53:726.

•Ruckart PZ et al. Long-term neurobehavioral health effects of methyl parathion exposure in children in Mississippi and Ohio. *Environ Health Perspect*, 2004, 112:46.

•Wagner SL et al. Chronic organophosphate exposure associated with transient hypertonia in an infant. *Pediatrics,* 1994, 94:94.

PESTICIDES AND CHILDHOOD CANCER

Some studies have found an association between postnatal pesticide exposure and an increased risk of paediatric cancer

- **Brain tumours**
- **Acute lymphocytic leukaemia**
- **Non-Hodgkin lymphoma**

A number of epidemiologic studies have found a significant association between cancer and domestic exposure to pesticides.

Evidence is increasing, but still limited because of the methodological weaknesses of the research.

Investigations in children living in the rural areas of developed countries have also produced limited evidence.

Refs:

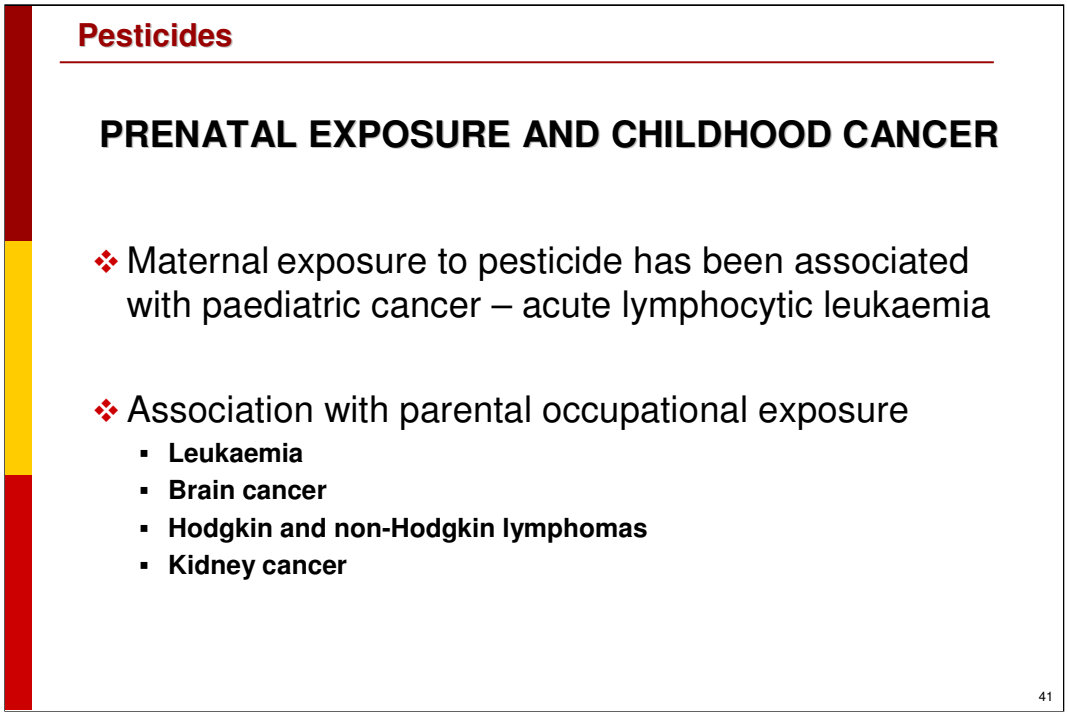
•Borkhardt A et al. Congenital leukaemia after heavy abuse of permethrin during pregnancy. *Arch Dis Child Fetal Neonatal Ed.* 2003, 88:F436.

•Daniels JL et al. Residential pesticide exposure and neuroblastoma. *Epidemiology,* 2001. 12:20.

•Leiss JK et al. Home pesticide use and childhood cancer: a case-control study. *Am J Public Health*, 1995, 85:249.

•Ma X et al. Critical windows of exposure to household pesticides and risk of childhood leukaemia. *Environ Health Perspect*, 2002, 110:955.

•Pogoda JM et al. Household pesticides and risk of pediatric brain tumors. *Environ Health Perspect,* 1997, 105:1214.



Prenatal exposure has been associated with leukaemia in a newborn after intensive use of permethrin at home by the pregnant mother. Children with certain metabolic enzyme polymorphisms have an increased risk of acute lymphocytic leukaemia when exposed to pesticides *in utero* or during pregnancy (particularly 2,4-D herbicide). Brain cancer appears to be associated to maternal exposure during agricultural activities. There are some controversial studies that suggest an increased risk of cancer in children whose parents had occupational exposure to pesticides.

Refs:

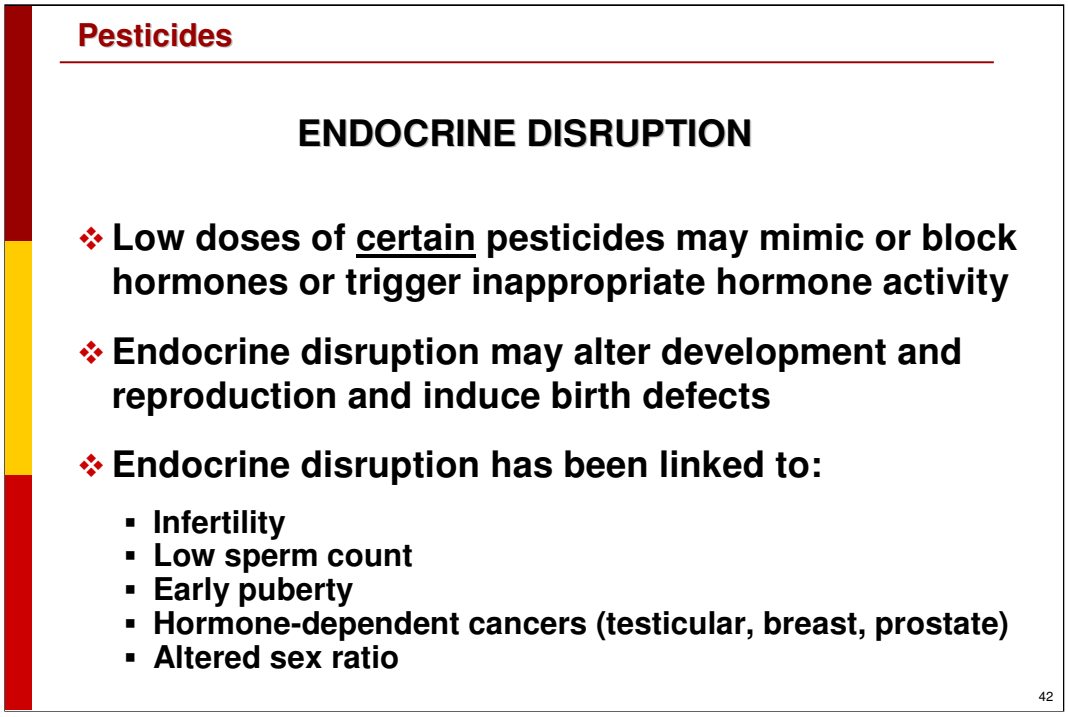
•Efird JT et al. Farm-related exposures and childhood brain tumours in seven countries: results from the SEARCH International Brain Tumour Study. *Paediatr Perinat Epidemiol*, 2003, 17:201.

•Flower KB et al. Cancer risk and parental pesticide application in children of agricultural health study participants. *Environ Health Perspect,* 2004, 112:631.

•Infante-Rivard C et al. Risk of childhood leukemia associated with exposure to pesticides and with gene polymorphisms. *Epidemiology,* 1999, 10:481.

•Rodvall Y et al. Cancer risk in offspring of male pesticide applicators in agriculture in Sweden. *Occup Environ Med,* 2003, 60:798.

•Zahm SH et al. Pesticides and childhood cancer. *Environ Health Perspect*, 1998, 106:893.



Endocrine disruption is not an effect, but a *mechanism* of toxicity that may have different effects.

Evidence of the effect related to this mode of toxicity in children is still limited.

There is experimental evidence of endocrine disruption. Pesticides may have:

•estrogenic effects (DDT, dieldrin, endosulfan, methoxychlor)

•anti-androgenic effects (DDT, vinclozilin, procymidone)

•anti-thyroid effects (ethylenethiourea (ETU), maneb, zineb metabolites)

•anti-progestin effects (DDT).

Synthetic pesticides may interfere with the natural process of development.

Refs:

•Baskin LS et al. Hypospadias and endocrine disruption, is there a connection? *Environ Health Perspect,* 2001, 109:1175.

•Damstra T et al. *Global assessment on the state of the science of endocrine disrupters*. IPCS. UNEP/ILO/WHO, 2002.

•Gray LE et al. Effects of environmental antiandrogens on reproductive development in experimental animals. *Hum Reprod Update,* 2001, 7:248.

•Landrigan P et al. Assessing the effects of endocrine disruptors in the National Children´s Study. *Environ Health Perspect,* 2003, 111:1678.

Pesticides

IMMUNOTOXICITY

- **Immunotoxicity is suspected, but evidence is limited**

Studies in Arctic zone:

- **Higher incidence of ear infections**
- **Cytokine panel abnormalities**



www.smithsonianmag.si.edu/smithsonian/issues04/jan04/images/topdogs_mush_jpg.html

43

Evidence on the immunotoxic mode of action and effects is limited. Studies from the Arctic zone and Europe are beginning to provide some evidence. Children contaminated with chlordane and heptachlor had cytokine panel abnormalities.

Inuit infants from the Artic exposed *in utero* and to breast milk contaminated with *p,p´*-DDE, hexachlorobenzene and dieldrin had an elevated risk of otitis media.

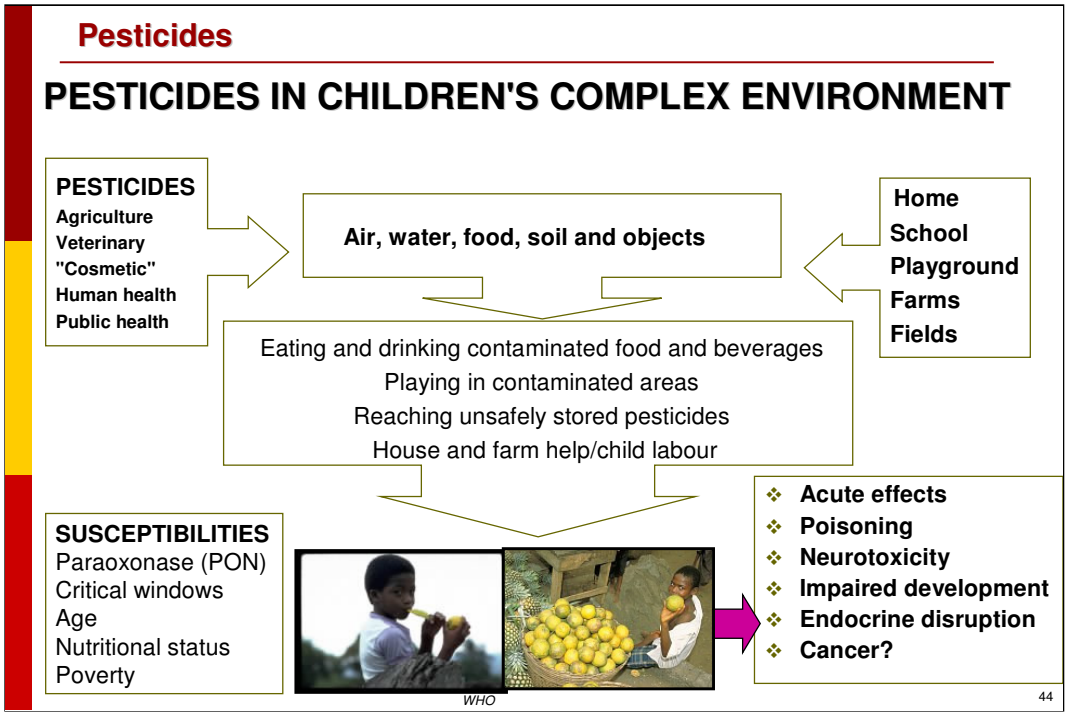
Refs:

•Dewailly E et al. Susceptibility to infections and immune status in Inuit infants exposed to organochlorines. *Environ Health Perspect,* 2000, 108:205.

•Duramad P et al, Expression of Th1/Th2 cytokines in human blood after in vitro treatment with chlorpyrifos, and its metabolites, in combination with endotoxin LPS and allergen Der p1, *J Appl Toxicol*, 2006, 26(5): 458-65.

•Phillips TM. Assessing environmental exposure in children: immunotoxicology screening. *J Exp Anal Environ Epidemiol,* 2000, 10:769.

Picture:
www.smithsonianmag.si.edu/smithsonian/issues04/jan04/images/topdogs_mush_jpg.html -
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This summary slide shows the complexity of the issues related to children's environmental exposure to pesticides and the effects on their health.

Pesticides used in agriculture, treatment of animals, on lawns ("cosmetic"), and for protection of human and public health may enter the air, food, water and soil in the places where children spend most of their time (e.g. at home, at school, in playgrounds, on farms and in fields) and may also contaminate their toys, floors, carpets and materials in their playgrounds.

Children become exposed by:

•eating and drinking contaminated food and beverages

•playing in contaminated areas

•gaining acces to unsafely stored pesticides, or pesticides stored in attractive, colourful containers

•helping in the house and on the farm or as child labour

•Contact with clothing or shoes of working parents

Children have special susceptibilities related to:

•paraoxonase (PON) - it catalyzes the hydrolysis of toxic metabolites and can protect against pesticide toxicity, which then depends on the PON genotypes

•critical windows of susceptibility

•age

•nutritional status

•poverty

Exposure may lead to:

•acute effects including irritation of the skin or eyes, coughing, lacrimation

•poisoning, with systemic effects

•neurotoxicity

•impaired development

•endocrine disruption

•cancer

<<NOTE TO USER: You may wish to replace this photo with an appropriate image of a child/children from your region.>>

Picture on the right: WHO, P. Virot. Fruits and vegetables, Ghana, 2003

Picture on the left: WHO, C. Gaggero. Jamaica, Nutrition and child

Pesticides

OBSOLETE PESTICIDES

Obsolete pesticides are pesticides that can no longer be used for their intended purpose or any other purpose.

They may include:

- Pesticides in liquid, powder or dust, granule, emulsion form.
- Empty and contaminated pesticide containers
- Heavily contaminated soil
- Buried pesticides

Causes of obsolete pesticides:

- Use prohibited for health/environmental reasons
- Product deteriorated as result of improper or prolonged storage
- Product not suitable for intended use and cannot be used for other purposes, nor can it easily be modified to become usable.

Obsolete, unwanted and banned pesticides are serious environmental hazards. Leaking and corroding metal drums filled with obsolete and dangerous pesticides dot urban and rural landscapes of developing countries around the world. These chemical leftovers have become villains in the agricultural world they were designed to help, affecting not only a nation's agriculture and its environment, but also fundamentally the health of its people and consequently development in general be it in rural areas or under urban conditions.

This global environmental tragedy is a direct result of several decades of mishandling and misuse, but is most dramatic in the developing world where there is no awareness of the inherent danger of pesticides. The unaware therefore draw water from contaminated site for own survival and that of their animals.

Obsolete pesticides may include: **<<READ SLIDE>>**

Most of the affected countries are under tropical conditions where agricultural and vector pests flourish both in diversity and numbers. Migratory pests such as locusts, grasshoppers, grain eating birds, storage pests, rodents, etc. inflict untold damage to agriculture and bring about hunger or misery when they are at their peak.

Poor nations have been led to believe that the only alternative to combat pests agricultural or otherwise effectively is only by using pesticides. The poor or the unaware never think for a moment that pesticides are poisonous and that they are dangerous to life. Most believe that pesticides are like medicines. They consider that they kill pests selectively and are therefore less harmful to humans, animals and plants. Governments save budgets to purchase pesticides on regular basis. Also constantly plead to donors and organizations for assistance either for direct supply of pesticides or for contributions of financial support for purchasing them. In response, donors and organizations supply pesticides.

Recipient countries anxious to minimize pest damages to the minimum or, being less aware of the negative consequences, usually receive pesticides from every possible source and direction. This leads to uncoordinated influx of pesticide donations and trading, subsequently giving rise to excessive supply. While some of the donations are genuine, others take the opportunity to dump unwanted and illegal pesticides on the poor and unsuspecting countries. Pesticides reach individual farmers or household dwellers that value pesticides dearly. They keep them in their houses, with their food and animals. Pesticide vendors take the opportunity to promote pesticides aggressively. It is not uncommon to find pesticides being stored in the open or in heavily populated zones and usually in substandard stores and sold along with food and drinks, etc. Children are used in advertising sales of pesticides and often get easy access to pesticides.

They play with empty pesticide cans and use them for drinking water or milk. Most pesticide cans litter high streets or are simply dumped in open municipality dumps for subsequent open burning leading to serious emissions of dioxins.

Common causes of obsolete pesticides include the following:

•Use of the product has been prohibited or severely restricted for health or environmental reasons (e.g. through banning; withdrawal of registration, or policy decision by relevant government agencies)

•The product has deteriorated as a result of improper or prolonged storage and can no longer be used according to its label specifications and instructions for use, nor can it easily be reformulated to become usable again.

•The product is not suitable for its intended use and cannot be used for other purposes, nor can it easily be modified to become usable.

Other possible reasons for why we have obsolete pesticide include:

•Banning of pesticides that are still kept in store.

•Aggressive pesticide sales, promotions and distributions by the Chemical Industry.

•Difficulties in forecasting outbreaks of pest.

•Inappropriate assessment of pesticide requirements.

•Insufficient application capacity.

•Inappropriate formulations or substandard containers.

•Excessive donations: these are usually inappropriate because they are not received when needed most (i.e. late arrival of donations or out of season delivery), or are uncoordinated with similar donations from various sources. Such are tantamount to dumping.

•Inadequate storage facilities and lack of staff trained in storage management (i.e. poor stock taking and lack of records).

•Ineffective distribution or poor marketing systems for pesticides (government or private sector or both).

•Lack of awareness of the inherent dangers of pesticides.

•Misuse of pesticide containers (e.g. for a variety of domestic uses, water containers, food storage, use for pot plants, etc.).

Notes from FAO: www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/Disposal/index_en.htm

OBSOLETE PESTICIDES

Disposal of obsolete pesticides:

- United Nations Food and Agriculture Organization has developed a set of guidelines for disposal.
- Contact your local authorities for advice on disposal.



FAO

Disposal of obsolete pesticides:

•In many countries, obsolete pesticides are a problem. The United Nations Food and Agriculture Organization have developed a set of guidelines for disposal, available at: *www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/Disposal/index_en.htm*.

•Contact your local authorities for advice on disposal.

WHO Recommended Classification by Hazard contains a table of active ingredients (available at: www.inchem.org/documents/pds/pdsother/class.pdf) believed to be obsolete or discontinued for use as pesticides.

<< NOTE TO USER: Do you have stockpiles of obsolete pesticides in this country? If so, what is the reason for it?>>

Notes from FAO:
www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/Disposal/index_en.htm

Picture: FAO, I. Balderi. Obsolete pesticides that have heavily leaked into the environment polluted and contaminated ground water and containers left from domestic use have disappeared into the soil.

Pesticides

PREVENTION OF EXPOSURE

What can be done to prevent pesticide exposure and poisoning ?



WHO

❖ **Take action at**

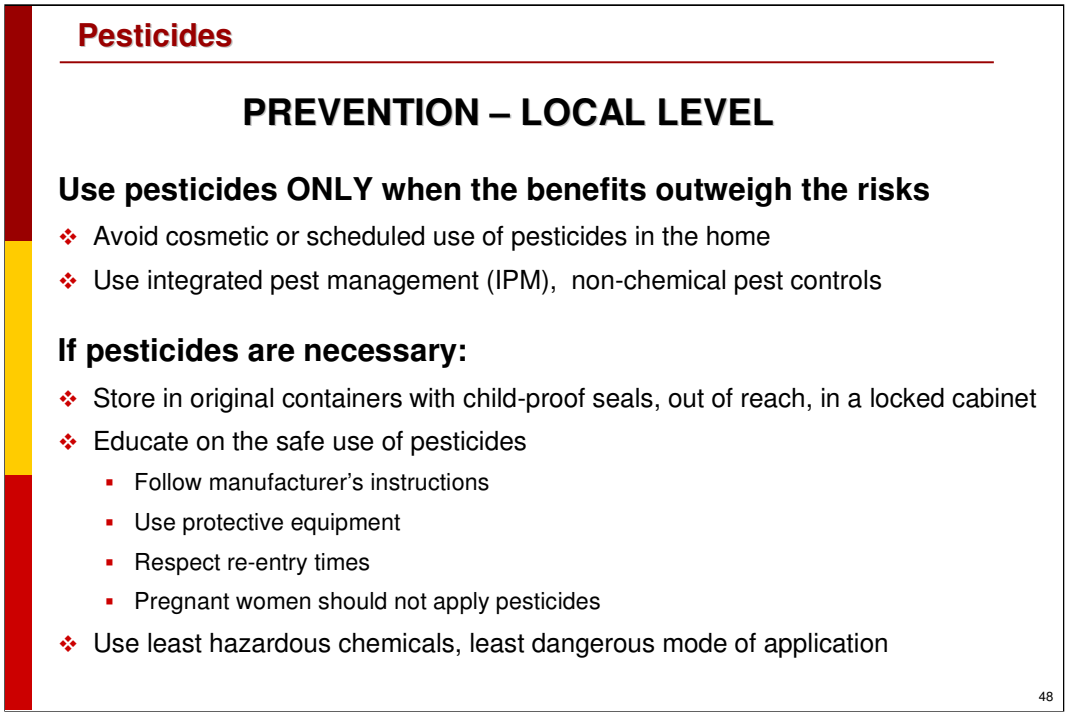
- **Local level**
- **National level**
- **International**

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<<READ SLIDE.>>

Because of the potential for long-term damage to critical structures such as the nervous system, immune system and endocrine system, prevention of all acute poisoning events as well as of exposure to low doses during development is a high priority for ensuring children's environmental health. There are many steps that can be taken at the local/practice level, national/government level and international treaty/trade levels to decrease exposure to pesticides and related illnesses.

Picture: WHO, L. De Toledo. Ethiopia



Pesticides should be used only when the benefits outweigh the risks, and non-chemical pest control procedures have failed.

Cosmetic use of pesticides, that is their use to control aesthetically unpleasant plants or non-dangerous insects such as crickets or house millipedes, should be completely avoided.

Integrated pest management (IPM) procedures which include hygiene, sealing of cracks and crevices, screening of doors and windows, and other measures should be the first line of defence for pest management.

If pesticides must be used, they should be stored only in their original containers with manufacturer's labels intact, preferably with child-proof seals, out of the reach of children and in locked cabinets or cupboards.

Users should always follow the safety precautions specified by the manufacturer and observe all safety recommendations including use of gloves, masks, protective clothing and observation of re-entry times (the time when it is safe to return to a treated area).

Pregnant women should not apply pesticides and particular care should be taken to determine appropriate re-entry times for pregnant women, infants and small children. These times may be considerably longer than for less vulnerable individuals.

If chemicals are required, the least hazardous chemical (when there is scientific evidence of less toxicity) should be used with the most contained mode of distribution considered effective. For example, fogs and bombs should not be used. Bait stations are preferable to baseboard sprays or crack and crevice treatment. Granules and bait stations should be used only if they are inaccessible to babies, toddlers and small children (and pets).

Refs:

•UNEP Chemicals. *Childhood Pesticides Poisoning. Information for Advocacy and Action. May 2004* (www.who.int/ceh/publications/en/pestpoisoning.pdf).

•US EPA Webpage for Integrated Pest Management (www.epa.gov/pesticides/food/ipm.htm).

Pesticides

PREVENTION – COMMUNITY LEVEL

- **Integrated pest management (IPM)**
  - **Homes**
  - **Schools**
  - **Public buildings**
  - **Health centres**
  - **Public parks**
- **Community activities**
  - **Community campaigns**
  - **School activities**
  - **Local awards or contests**
  - **Pesticide-free "zones"**
  - **Support organic farming**



WHO

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Many organizations (especially FAO and WHO) promote alternative non-chemical forms of pest-control and there is increasing engagement in non-pesticide dependent agriculture and integrated pest management (IPM).

A variety of local initiatives involving the community can help to create an environment that promotes decreased dependence on pesticides in homes, schools, public areas, health facilities and parks.

Examples of community activities include:

•community campaigns and school activities

•local awards or contests

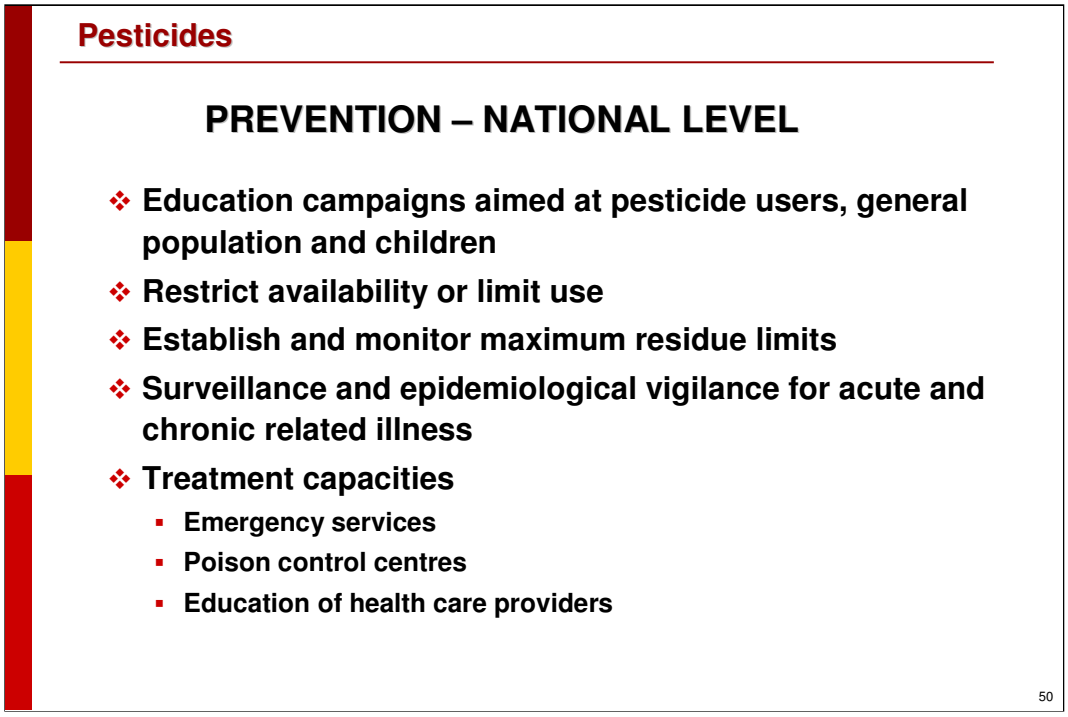
•pesticide-free "zones“

•support for organic farming

FAO: Food and Agriculture Organization

<<READ SLIDE.>>

Picture: WHO, P. Virot. Plants at the Biofarm, Ethiopia, June 2002.



Education is a key component of safe pesticide use and prevention of toxic exposures. Farmers, pesticide applicators and their families need to be informed and educated on how to recognize and prevent pesticide poisonings. Trained or licensed pesticide applicators can maximize preventive measures.

Bans and restrictions on use of pesticides found to be highly toxic or persistent in the environment have been successful; severe poisonings are seen less frequently than in the past. For example, organochlorine poisoning no longer occurs in countries that restrict their uses to a specific agricultural application and have banned domestic use.

A major change in regulatory approaches to pesticides occurred when the US Congress passed the Food Quality Protection Act in 1996. This law requires the US Environmental Protection Agency to set residue levels for foods to protect the most vulnerable populations, specifically infants, children and fetuses (pregnant mothers) from harm due to cumulative exposure taking into account all routes of exposure. This law has led to the restrictions on use and voluntary withdrawal from the market by manufacturers of several previously widely used pesticides (e.g. chlorpyrifos and diazinon).

Pesticide manufacturers and governments should follow the voluntary FAO International Code of Conduct on the Distribution and Use of Pesticides.

Refs:

•UNEP Chemicals. *Childhood Pesticides Poisoning. Information for Advocacy and Action. May 2004* (www.who.int/ceh/publications/en/pestpoisoning.pdf).

•US EPA Website Food Quality Protection Act, 1996 (www.epa.gov/oppfead1/fqpa/backgrnd.htm).

Pesticides

PREVENTION – INTERNATIONAL LEVEL

- **Persistent organic pollutants (POPs) Stockholm Convention**
- **Hazardous chemicals and pesticides Rotterdam Convention (PIC)**
- **International organizations: WHO, IFCS, FAO, ILO**



Pronczuk 51

Nine of the 12 persistent organic pollutants (POPs) included in the Stockholm Convention, are pesticides (aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex, toxaphene and hexachlorobenzene). This convention, under the auspices of United Nations Environmental Programme became effective in May 2004, after it was signed by 50 countries.

The Rotterdam Convention on the Prior Informed Consent (PIC) procedure for certain hazardous chemicals and pesticides was adopted in September 1998, and has been signed by 73 countries. The convention establishes a first line of defence against toxic chemicals, giving importing countries the power to receive information and decide which potentially hazardous chemicals they want to receive. It also covers labelling requirements. The convention includes 22 pesticides.

Other international organizations such as the Intergovernmental Forum for Chemical Safety (IFCS), the International Labour Organization (ILO) and others are working towards safer use and monitoring of pesticides at the global level.

IFCS: Intergovernmental Forum for Chemical Safety

FAO: Food and Agriculture Organization

ILO: International Labour Organization

Refs:

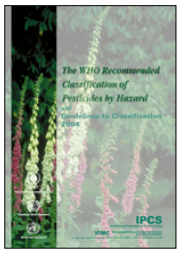
•UNEP Chemicals. *Childhood Pesticides Poisoning. Information for Advocacy and Action. May 2004* (www.who.int/ceh/publications/en/pestpoisoning.pdf).

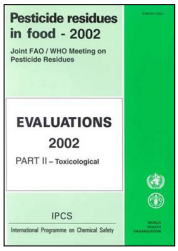
•www.pic.int

Pesticides

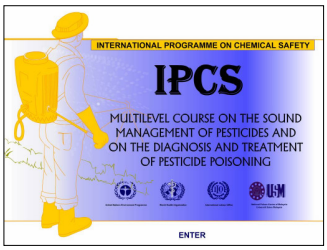
PESTICIDES AND CHILDREN: ACTIVITIES IN WHO

1. **Guidelines for the classification of pesticides by hazard**
2. **Joint FAO/WHO Meeting on Pesticide Residues**
3. **International pesticide limits in water**
4. **Training manual on pesticides**
5. **Poison centres and pesticide exposures**









WHO

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1. WHO guidelines for the classification of pesticides by hazard. The WHO Recommended Classification of Pesticides by Hazard was approved by the 28th World Health assembly in 1975 and has since gained worldwide acceptance. Guidelines were first issued in 1978, and have since been revised and reissued at 2-yearly intervals. *Ref: IPCS. The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 2000-2002.* Geneva, World Health Organization, 2002.

2. The Joint FAO/WHO Meeting on Pesticide Residues (JMPR) is an international expert scientific group that is administered jointly by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO). JMPR, which consists of the FAO Panel of Experts on Pesticide Residues in Food and the Environment and the WHO Core Assessment Group, has been meeting regularly since 1963. During the meetings, the FAO Panel of Experts is responsible for reviewing information on residues and analytical aspects of the pesticides under consideration, including data on their metabolism, fate in the environment, and use patterns, and for estimating the maximum levels of residues that might occur as a result of the use of the pesticides according to good agricultural practices. The WHO Core Assessment Group is responsible for reviewing toxicological and related data and for estimating, where possible, acceptable daily intakes (ADIs) for humans of the pesticides under consideration.

Ref: www.who.int/ipcs/food/jmpr/en

The Codex Alimentarius Commission was created in 1963 by FAO and WHO to develop food standards, guidelines and related texts such as codes of practice under the Joint FAO/WHO Food Standards Programme. The main purposes of this Programme are protecting the health of the consumers and ensuring fair trade practices in the food trade, and promoting coordination of all work on food standards undertaken by international governmental and nongovernmental organizations. Ref: www.codexalimentarius.net/web/index_en.jsp

3. International pesticide limits in water. WHO produces international norms on water and health in the form of guidelines.

Ref: www.who.int/water_sanitation_health/dwq/guidelines/en/

4. Training manual on pesticides. Available at IPCS (WHO).

5. Poison centres play a key role in providing information, advice and management of case of pesticide exposure in the countries where they are available. For more information, *see*: www.who.int/ipcs/poisons/centre/directory/en/

IPCS: Intergovernmental Programme on Chemical Safety

FAO: Food and Agriculture Organization

Pictures: WHO

CRITICAL ROLE OF HEALTH AND ENVIRONMENT PROFESSIONALS



WHO

- Diagnose and treat
- Publish, research
  - Sentinel cases
  - Community-based interventions
- Educate
  - Patients and families
  - Colleagues and students
- Advocate
- Provide role model

Health and environment professionals have a critical role to play in maintaining and stimulating changes that will restore and protect children's environmental health, and protect them from pesticide exposure.

Health care providers can do something. At the one-to-one level with the patient, they can include pesticide poisoning in the differential diagnoses and in preventive advice. They can be dissatisfied with the diagnosis of "idiopathic" in cases of paediatric disease and look harder for evidence pointing to pesticides as a potential cause of disease and disability. They can ask specific questions about the use of pesticides within the home, in the garden or farming areas, or about potential pesticide residues in fruit and vegetables. Which pesticides are being used? When? Where? How? What safety and hygiene measures are being taken? Are the instructions being read and followed?

They can publish sentinel cases and develop and write about community-based interventions in relation to pesticides. They can educate patients, families, colleagues and students didactically to diagnose, treat and prevent pesticide poisonings and exposures. They can discourage chemical pesticide use and encourage integrated pest management. They can also provide information about the local Poisons Centre or other sources of information on pesticides.

As professionals with an understanding of both health and the environment, health care providers are powerful role models who can practice integrated pest management, be advocates for strict pesticide laws and regulations, proper labelling of pesticide products and child-proof containers for all pesticide products.

POINTS FOR DISCUSSION

<<NOTE TO USER: Add points for discussion according to the needs of your audience.>>

Pesticides

CASE STUDY

- **A family with two children ages 8 months and 6 years are referred to the clinic with concerns of pesticide exposure.**
- **They are worried because their apartment was sprayed with pesticides for termites 3 times when the mother was pregnant with her 6 year old son. She remembers feeling dizzy and fatigued during that period but attributed it to the pregnancy.**

<<READ SLIDE>>

The setting is present day New York City, United States. This family is poor and lives in low income housing that was likely sprayed multiple times for termites. The most commonly used pesticide at that time was chlorpyrifos.

Pesticides

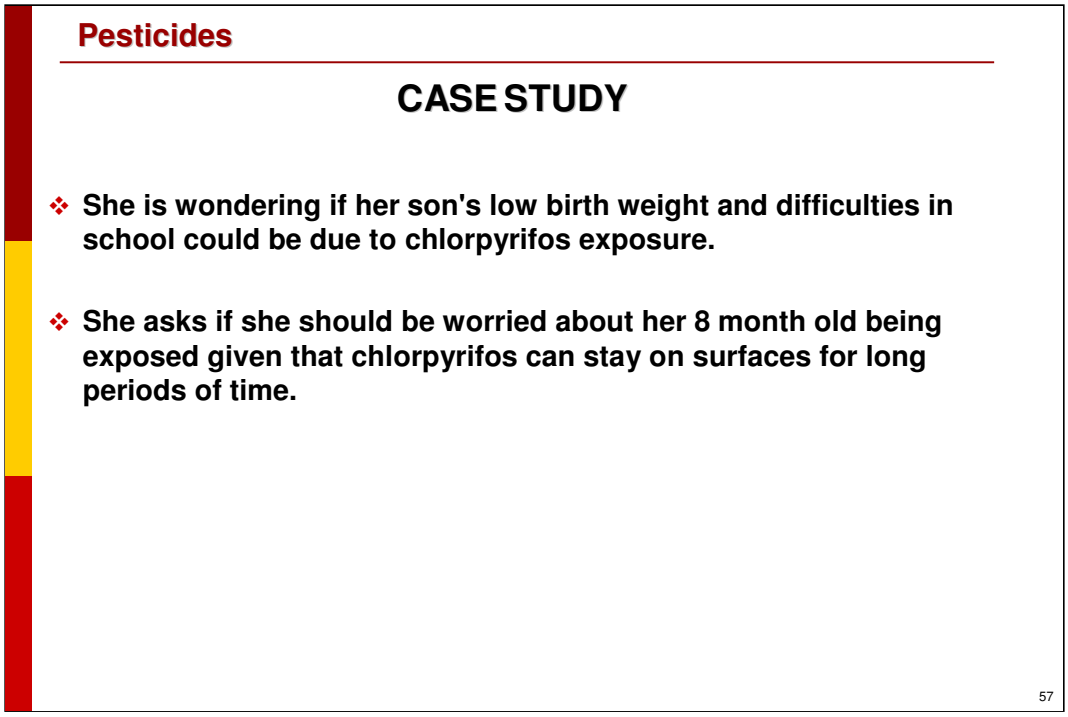
CASE STUDY

- **Her six year old was born at low birth weight for gestational age and has been behind in meeting developmental milestones. He now has behavioural problems and is behind in reading in school.**
- **She recently read in the newspaper that chlorpyrifos is not being used in residential settings in the US because it stays on surfaces for long periods of time and may have harmful health effects.**

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Read the Slide

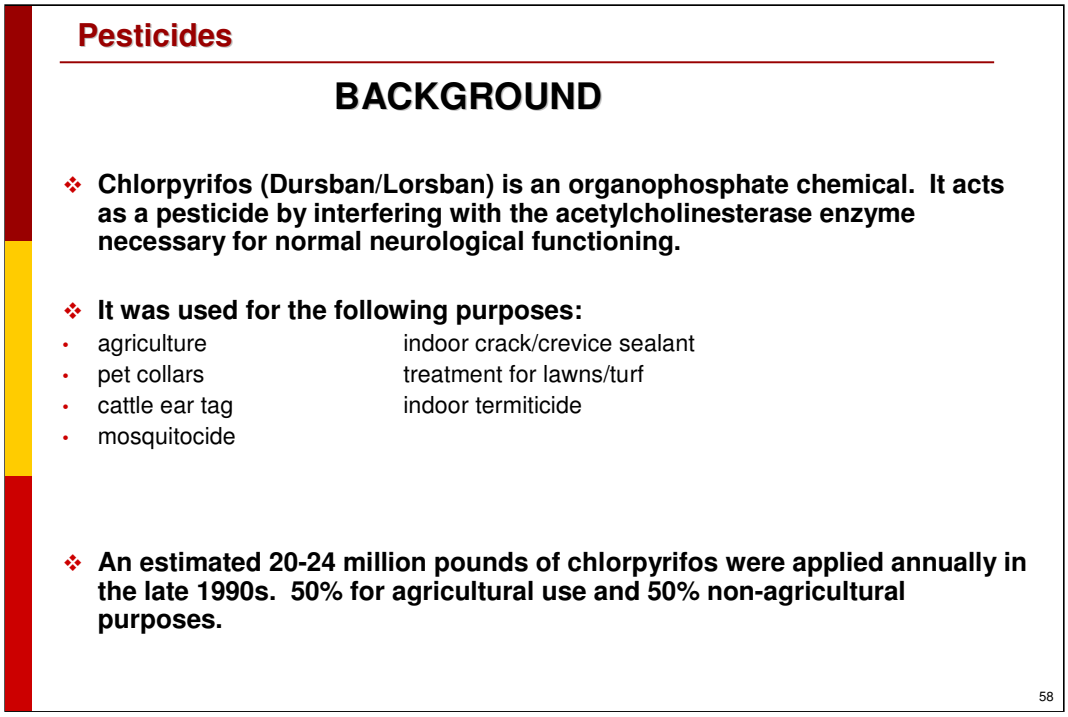
The mother was told by someone at work that there was a newspaper article on a pesticide (chlorpyrifos) that was widely used in their part of New York. It stated that the the US Environmental Protection Agency phased out its use because of adverse health effects. The article pointed out that mothers who were exposed to chlorpyrifos prenatally may have delivered low birth weight babies.



As we know, pediatricians treat the entire family not just individual children. This case brings up a number of interesting points regarding each family member.

Pre-Test

1. What are the problems lists for the 6 year old and 8 month old?
2. What differential diagnoses would you consider for the 6 year old?
3. What further history do you want?
4. How would you further evaluate and manage these patients?
5. What is the likelihood that prenatal chlorpyrifos exposure is related to the 6 year old's health problems?



Chlorpyrifos is in the organophosphate family of chemicals. It is a known human toxin that persists in the environment for decades. Chlorpyrifos is released into the environment and can travel through waterways and sediments to enter the food supply by way of farming or the fish/animal supply. It is ubiquitous in all parts of the world.

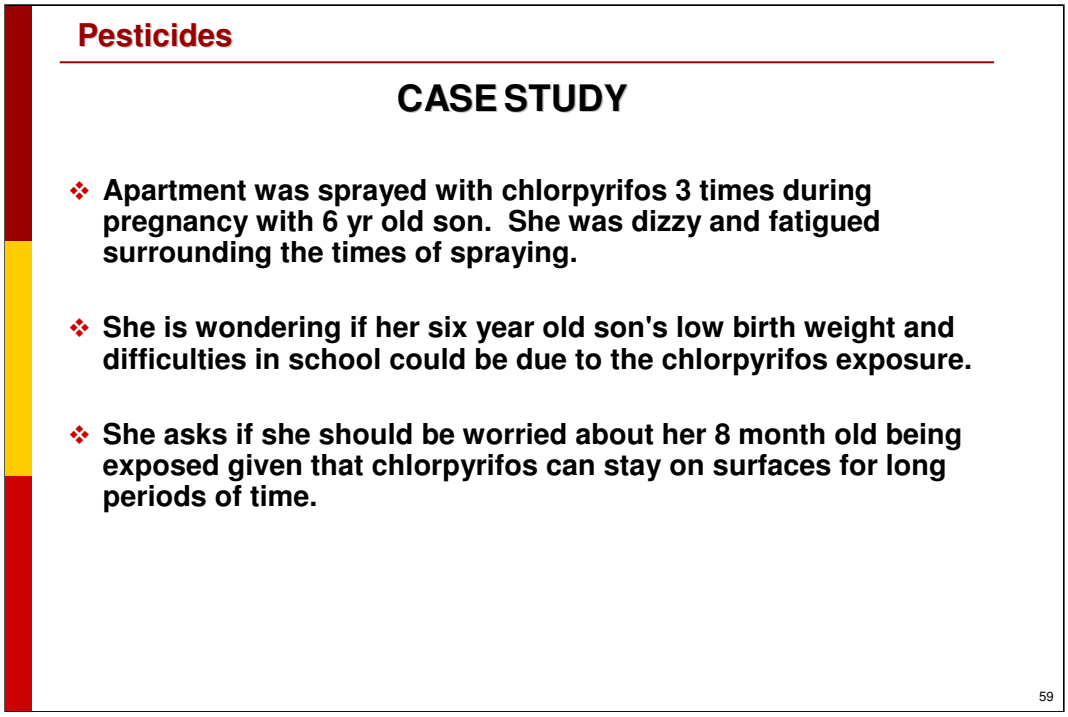
It has been used in farming extensively as a pesticide thereby exposing numerous food crops to its residues.

It has been used as an insecticide for termites and mosquitoes. It has been used as an indoor crack/crevice sealant, for pet collars, and as treatment on lawns, turf or pastures.

US EPA estimates that 20-24 million pounds of chlorpyrifos were applied annually in the late 1990s. Mitigation measures were put into place in the US in 2000 to phase out uses near or in schools, homes, parks, and daycare centers and to restrict uses in agricultural settings.

Ref:

US EPA Website Organophosphate Pesticide Information



Now, let's go back to the original case.

What does this information tell you and what more do you want to know?

1. First, this mother was exposed when she was pregnant. We would like to know the exact chemicals used and have documentation of the exposure. Also, we need to take a thorough environmental history:
- Exposures to other environmental toxicants (there may be other substances in the household contributing to her health effects during pregnancy)
- What are the occupations of the parents? Are there potential environmental exposures at work?
- When is/was the exposure? Is it continuing currently?
- What are the main effects? We would like to know more about the mother's symptoms during pregnancy (although there does not need to be overt clinical symptoms for low level toxicity).

2. In terms of the six year old son – we would like to know his birth weight, length, and head circumference
- How has his growth has been?
- What is his developmental history?
- What are his activities and what he might be exposed to in the environment?

3. In terms of the 8 month old, we would like to know if he is crawling currently (exposure to floor, carpets, furniture).
- Is he still breastfeeding?
- How has his development been?

ANSWERS

Overall, there are not clear cut answers in low dose exposure toxicology as compared to acute exposures. All answers must weigh the scientific evidence of the toxicant against the clinical history and physical exam findings of the patients.

1. Chlorpyrifos exposure in high doses is associated with dizziness and fatigue. The differental diagnosis for her symptoms is long and, it is difficult say whether the mother's symptoms were due to this exposure given that most residential chlorpyrifos sprayings were not associated with overt toxicity.
2. Her son's low birth weight and difficulties in school may be due to a number of factors. Chlorpyrifos has been associated with low birth weight and decreased birth length in inner city newborns whose mothers were exposed during pregnancy. Long term neurodevelopmental outcomes have not been studied to date.
3. The 8 month old is crawling and being exposed to many surfaces in the home. The data has shown that higher levels of chlorpyrifos are inversely correlated with time from application to testing. Most of this data shows that residues persist for 1-2 wks after spraying but with multiple exposures, residues may persist longer.

CASE STUDY

What recommendations would you give to this family?

- **Primary prevention!**
- **Encourage home dust/furniture testing if they think exposure is ongoing**
- **Encourage blood testing for acetylcholinesterase if they are worried about ongoing exposures**
- **Encourage alternatives to pesticides for the future**

Pesticides

ACKNOWLEDGEMENTS

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Pesticides

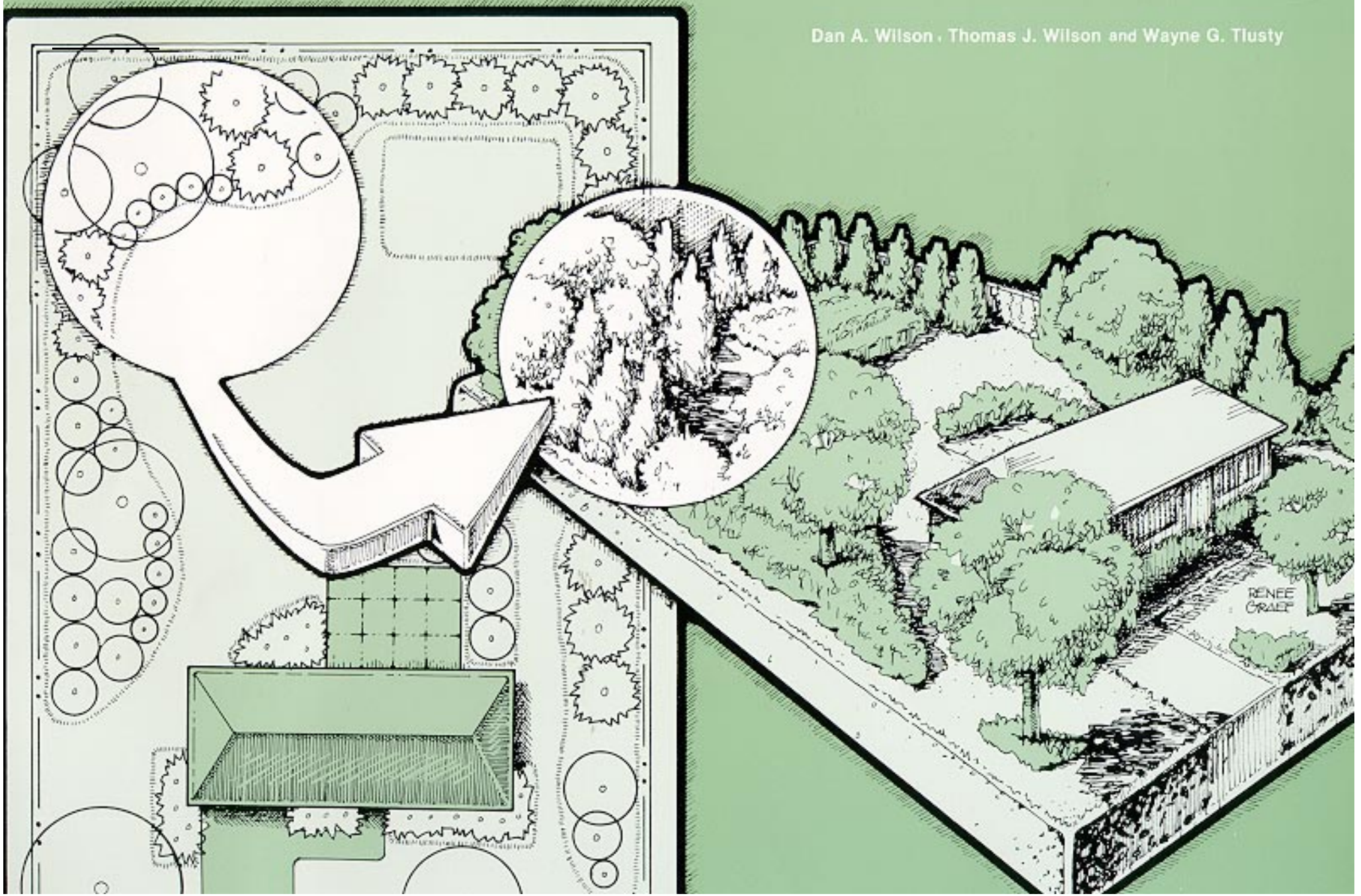
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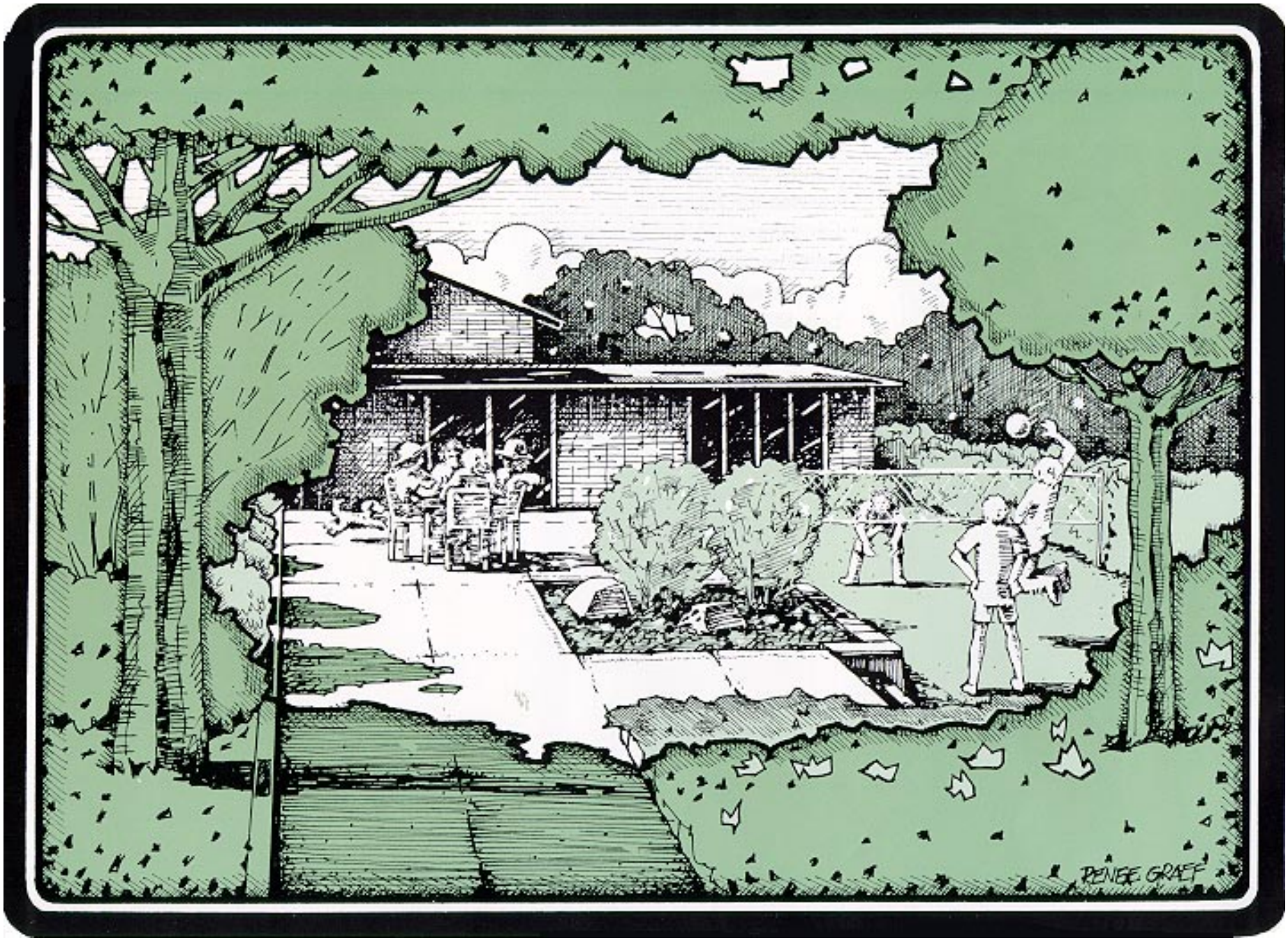
Planning and Designing Your Home Landscape

Dan A. Wilson, Thomas J. Wilson and Wayne G. Tlusty



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RENEE GRAEF

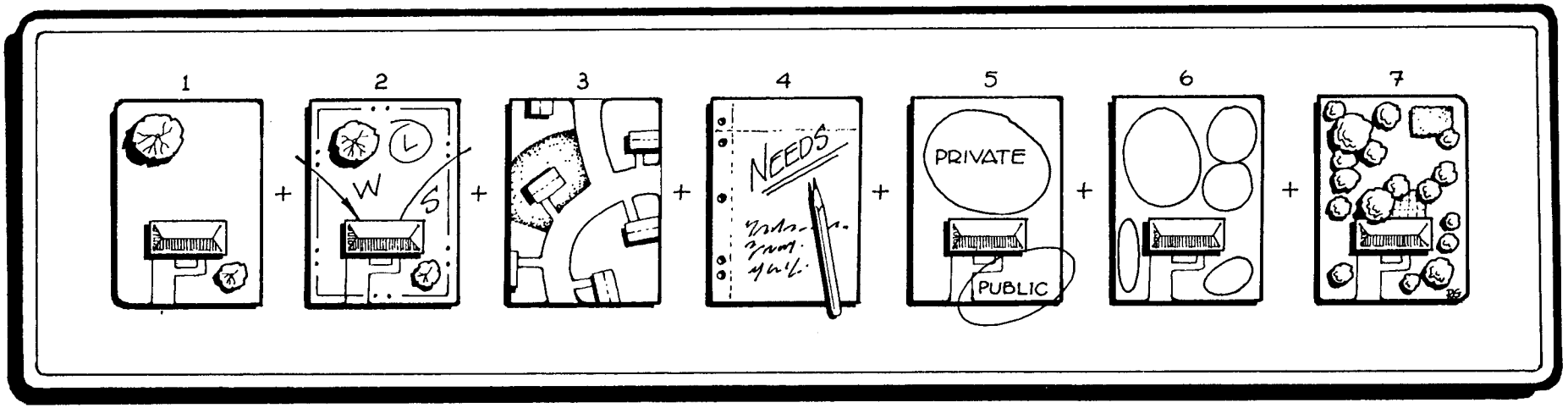
Introduction

The area around your home is an important part of your living environment. Attractively and functionally landscaped, it can add to your enjoyment of your home. Landscaping can also increase property value, invite wildlife into your yard and conserve energy.

Successful landscaping does not just happen. It requires careful planning and some knowledge of landscape design. You have to consider your home's architectual features, neighborhood landscape character, the effects you want to create, and how you want to use your outdoor living space. It may take several years of planting and construction to achieve your goals, but the first step is planning and designing what you want to end up with.

This publication will guide you step-by-step through planning and designing a landscape appropriate for you and your home. It was written with only slightly landscaped or unlandscaped homes in mind. We emphasize "conventional" landscape design, which usually includes flowers, shrubs, trees and structures arranged in various patterns.

You can get many other landscaping ideas from books, magazines and other publications. Some homeowners may prefer to have a professional landscape architect or landscape nurseryman develop a landscape design.



Landscape Style Options

In the past, most home landscapes were either formal or informal. Formal designs are geometric and symmetrical, with plants and landscape structures precisely spaced and arranged. Informal designs make use of more natural-appearing, irregularly placed plants and structures.

Today, more people want their home landscape to meet physical and social needs. Partly as a result of the environmental movement, which fostered a greater appreciation for nature, we tend to be more interested in informal or naturalistic designs.

The geometric forms of buildings and natural landscape characteristics both suggest design patterns. As a result, a home landscape that blends geometric and naturalistic patterns is often successful. Today's landscape styles can be divided into categories in which varying proportions of geometric and naturalistic patterns are combined:

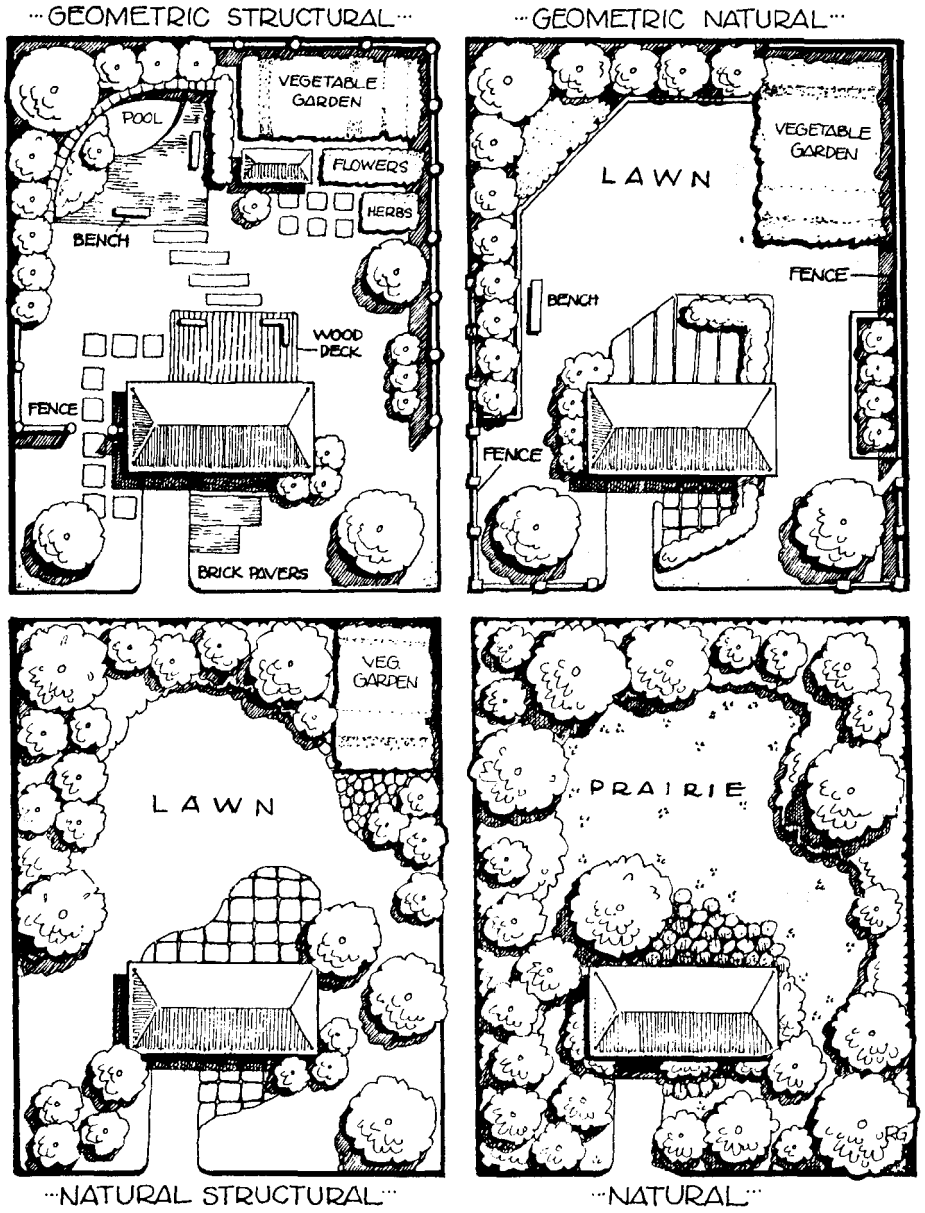
Geometric-Structural – geometric structure is primary and plants play a minor role.

Geometric-Natural – structure dominates, but plants and other natural elements play an important, perhaps nearly equal role.

Natural-Structural – plants, rocks, water and earth forms dominate, but there is a clear sense of geometric arrangement.

Natural – natural elements and materials dominate and there is no obvious human-determined form or structure.

As you go through the planning and design steps that follow, you should have in mind which of these general design styles you want to achieve.

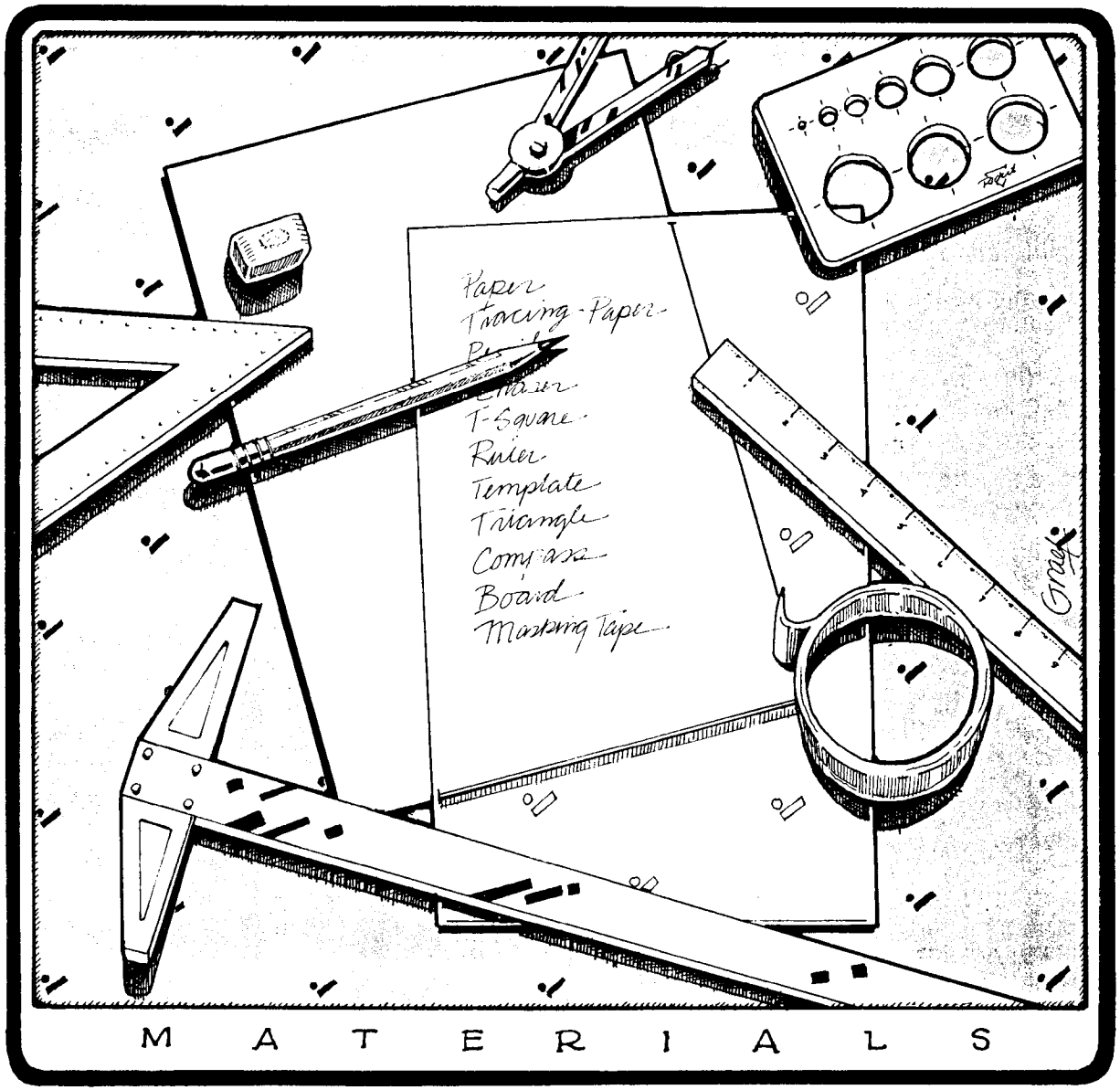


Landscape Planning

Too often, homeowners plant before they plan. Careful planning will help you avoid errors that may interfere with your final landscape design, such as improper plant selection or placement.

This section takes you through the required planning steps. You will find these items helpful:

–Large white paper or 1/10 or 1/8 inch graph paper (graph paper is easier to use)
–Solid table or board to draw on
–Masking tape to hold paper in place
–Ruler or scale marked in eights or tenths of an inch
–Lead pencil
–Eraser
–Lightweight, “see-through” tracing paper
–T-square, triangle, circle template and compass



Step 1. Draw a Base Map

If you own a new home, you probably have a lot or plot plan that shows your home in relation to the property boundaries. If you do not have such a plan to work from, you'll need to determine accurately – with a tape measure – where the house is located on the lot. In addition, determine:

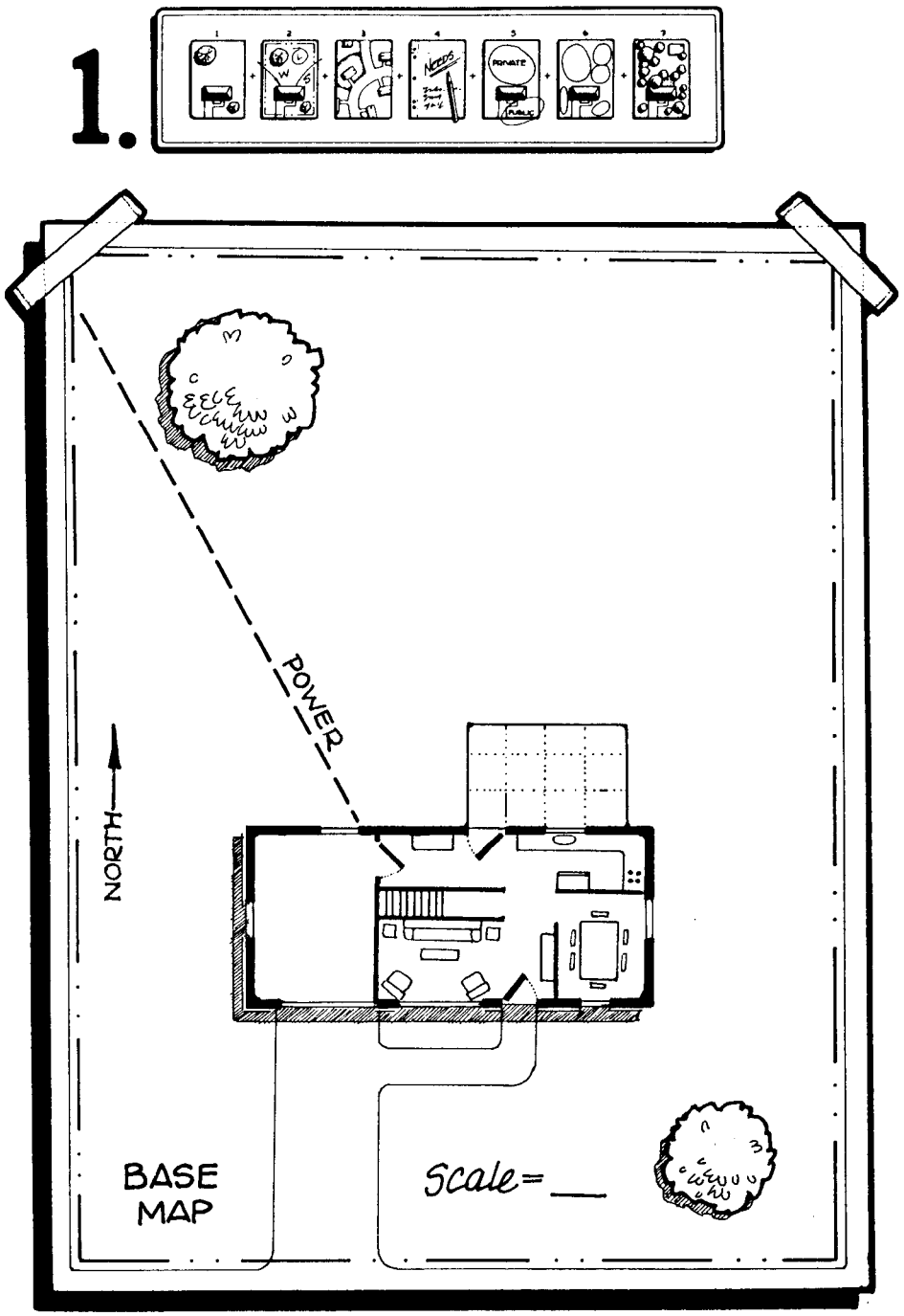
–Outside house dimensions
–Overhang dimensions
–Window and door locations
–Height from ground to bottom of windows
–Locations of water faucets, dryer vent, air conditioner, window wells, downspouts, electric and gas meters and fuel fill spout.
–Any other important exterior house features

Draw your lot lines on the paper. If you live on a large parcel of land, limit your base map to the area you plan to landscape. It's usually most convenient to draw at a scale of 1/8 or 1/10 inch per foot–1/8 inch or 1/10 inch on the paper equals 1 foot on the ground. In one corner of the paper, indicate which direction is north and the scale of your drawing.

Next, draw the location of your house, using the same scale. Indicate windows, doors, overhang and other exterior features. You'll need this information later to develop a successful planting design. Also sketch in interior room arrangements; this part of the drawing will help you consider views from inside the house and patterns of movement between yard and house.

Still using the same scale, draw in existing lot or yard features, including:

–Garage, if unattached
–Other buildings in the area to be landscaped (such as barn, silo and storage shed)
–Driveways and sidewalks
–Underground and overhead utility lines: electric, telephone, water and gas
–Septic tank (or drywell), drain field and vent or sanitary sewer lines
–Trees, shrubs, and other plants to be preserved (don't bother noting those you plan to remove)



Step 2. Analyze your lot or farmstead

To develop the best design, you need a physical and visual analysis of your lot or farmstead that takes into account both natural and man-made features.

Inventory the following categories of natural features on your lot:

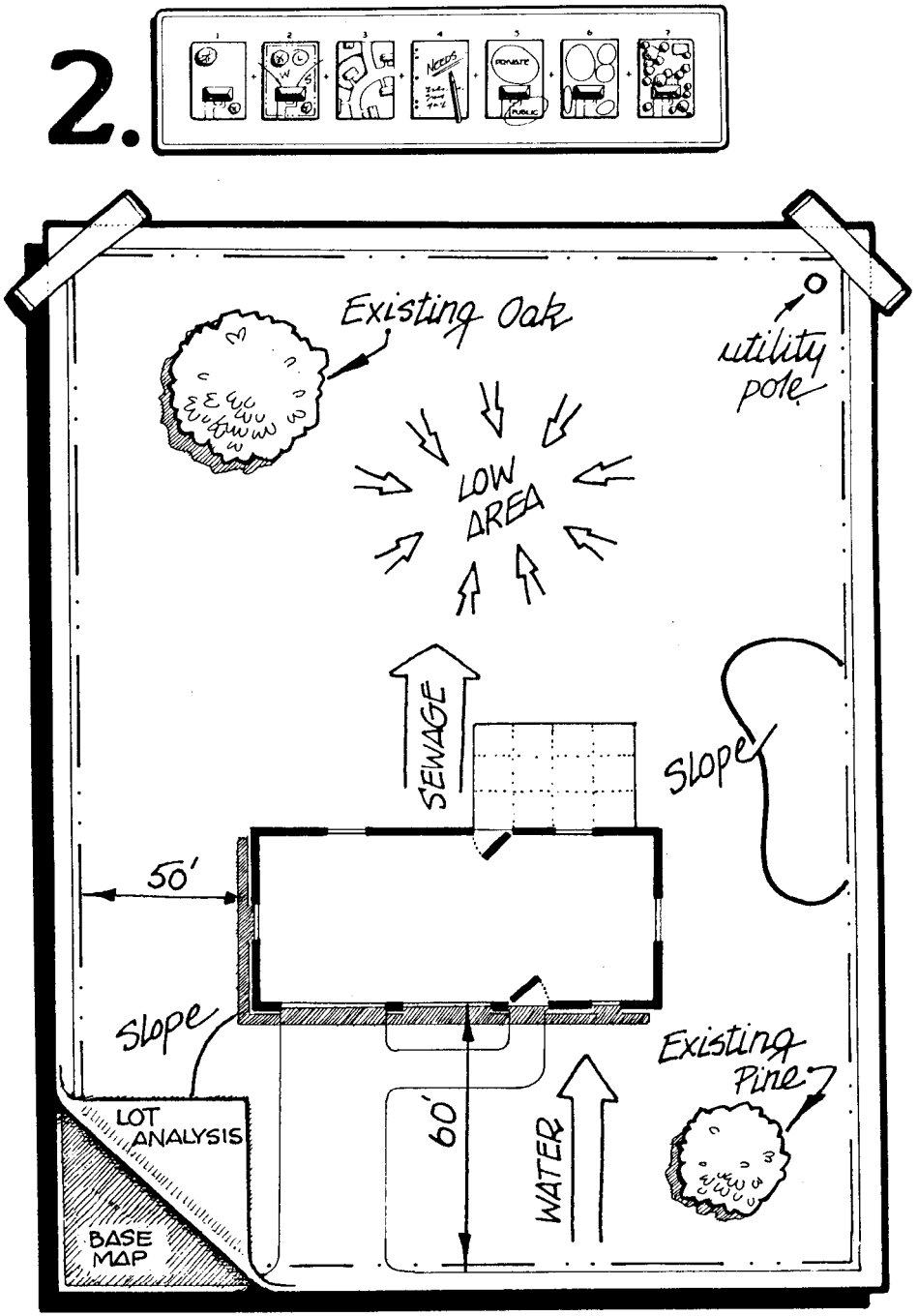
Vegetation. Your homesite may already have trees, shrubs or other plants. Before deciding whether to include them in your landscape design, you must know what kind of plants they are – some may be considered "weeds," while others may be valuable. Consider also the general appearance or quality of the plants, whether they interfere with the rest of your landscape design, and the shade and sun patterns they create.

Topography refers to the shape of the land's surface. Some lots are flat, while others have a variety of ground forms. It's important to decide whether the existing topography can be preserved or whether it must be modified to meet your family's outdoor needs.

The **drainage** patterns on your site may greatly influence your home landscape design. Note the direction of runoff and low spots where water may collect. Monitor drainage carefully to make sure that outdoor use areas will be suitably located, that water will move away from buildings and that plants will grow well where you place them.

Your lot or farmstead's **soil** is important because it must support both plants and man-made structures. Soil tests, available through your county Extension office, will tell you whether your soil has the proper chemical makeup for good plant growth. Your county Soil Conservation Service can determine whether the physical properties of your soil are suitable for landscape structures.

Climate will influence your landscaping plans in several ways. Winter temperatures determine which plants are hardy enough to grow on your lot. Spring and fall frost dates determine length of growing season. Average precipitation (about 30 inches for most of Wisconsin) may not be enough for some plants; but you can supply additional water. Humidity affects the spread and severity of plant diseases. In Wisconsin, prevailing winter winds are from the northwest, and most summer breezes come from the southwest. You will want to provide winter wind protection and to take advantage of summer breezes. The U.S. Weather Bureau and county Soil Conservation Service and Extension offices can provide climate information more specific for your location.



During your analysis, take into account man-made structures and natural landforms seen from your house and lot. You will probably want to screen from view such off-site “nuisances” as highways, power lines, industrial centers and junkyards while keeping or enhancing good views. You may also want to block out annoying noises from automobiles, trains and other sources.

It helps to take pictures of your lot or farmstead. Often we see only what the mind “wants” to see, rather than what really exists. Photographs or slides help you see the site as a visitor would. They also serve as reminders of what the house and site look like while you are working on your design.

Photos should include views of the house from all sides. Photos of off-lot views, from both inside and outside the house, will help you identify those you want to keep or enhance and those that should be screened for beauty or privacy.

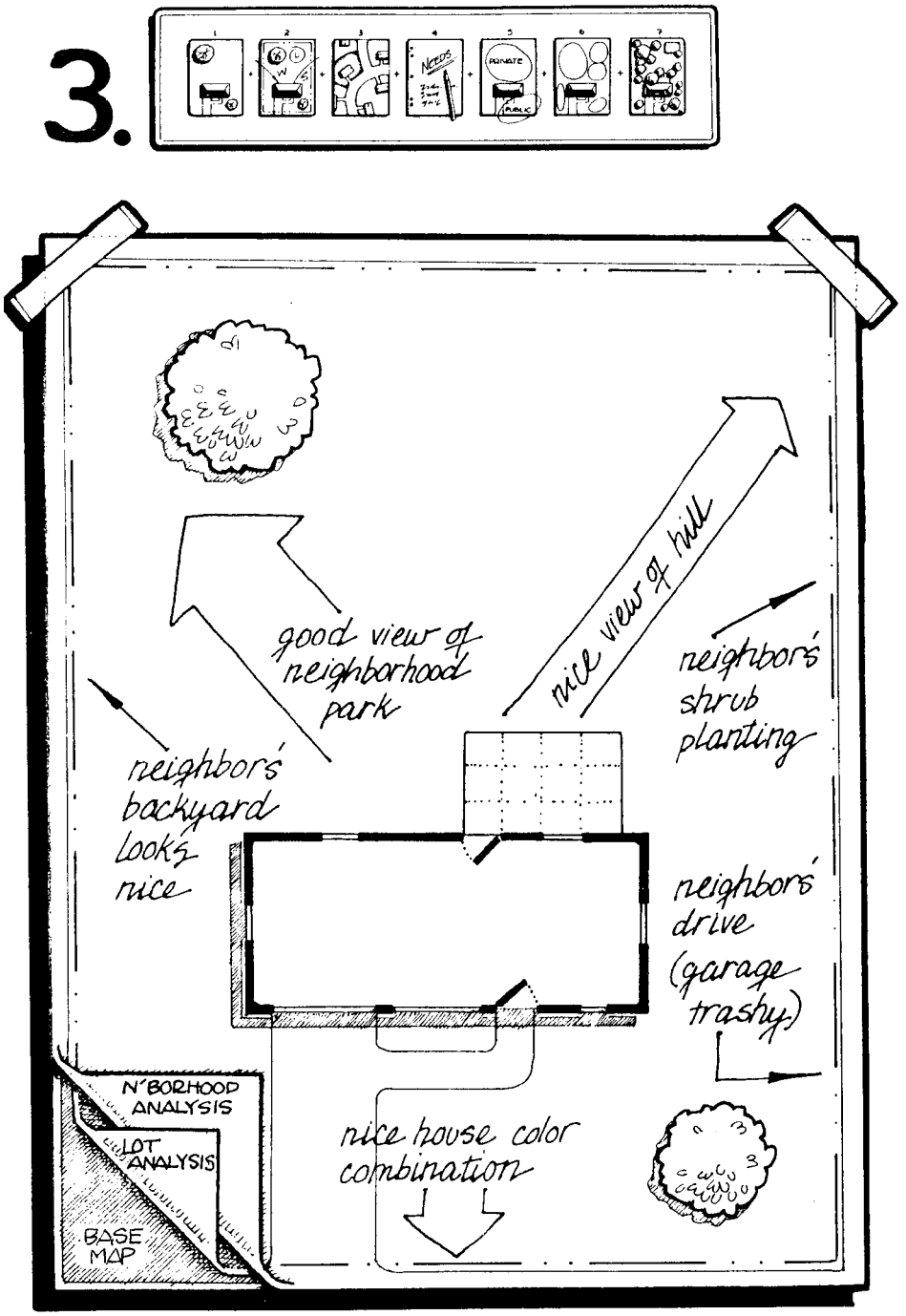
Record lot features by sketching them on tracing paper placed over your base map. On the tracing paper, indicate with arrows or other symbols:

–Major differences in land surface elevation – include hills, depressions and rock outrcroppings
–Topography and drainage patterns
–Prevailing summer and winter winds
–Good views to be kept or enhanced.
–Poor views and annoying sounds to be screened
–Other features that seem significant

Step 3. Analyze how your Lot or Farmstead Relates to the Neighborhood

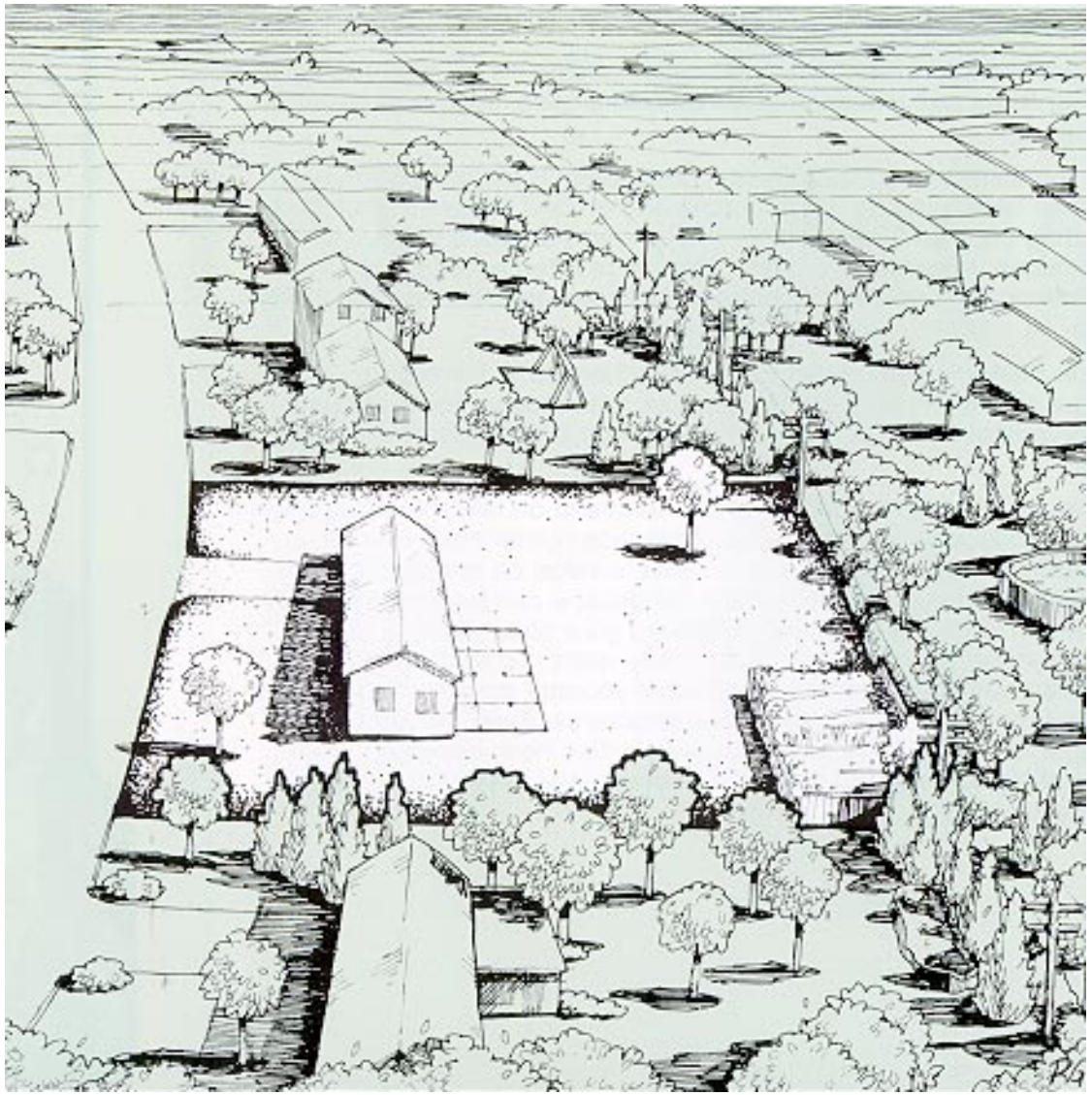
A survey of your neighborhood will suggest landscape possibilities. It will also help you avoid developing a design that is out of place.

Don’t be limited by neighborhood examples, but if you do decide to use a very different kind of design, do it unobtrusively-you may want to restrict its full impact to the back yard, for example. You may also want to share your plans with neighbors to gain their understanding and to get their suggestions.

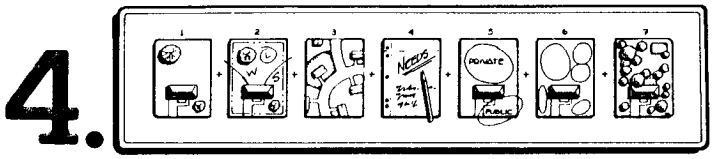


What building materials, colors, plants and types of screening have others used? Which home landscape in the neighborhood do you like or dislike? Earth-tone home colors, dark roofing materials, organic mulches and uniformly green foliage usually create a visually pleasing neighborhood.

Some communities have zoning, building setback and fencing and planting restrictions you should know about before making landscaping plans. Check with your town, village or city clerk or zoning administrator. You should also check deed and subdivision restrictions for other possible landscaping constraints.



Step 4. Analyze your Needs



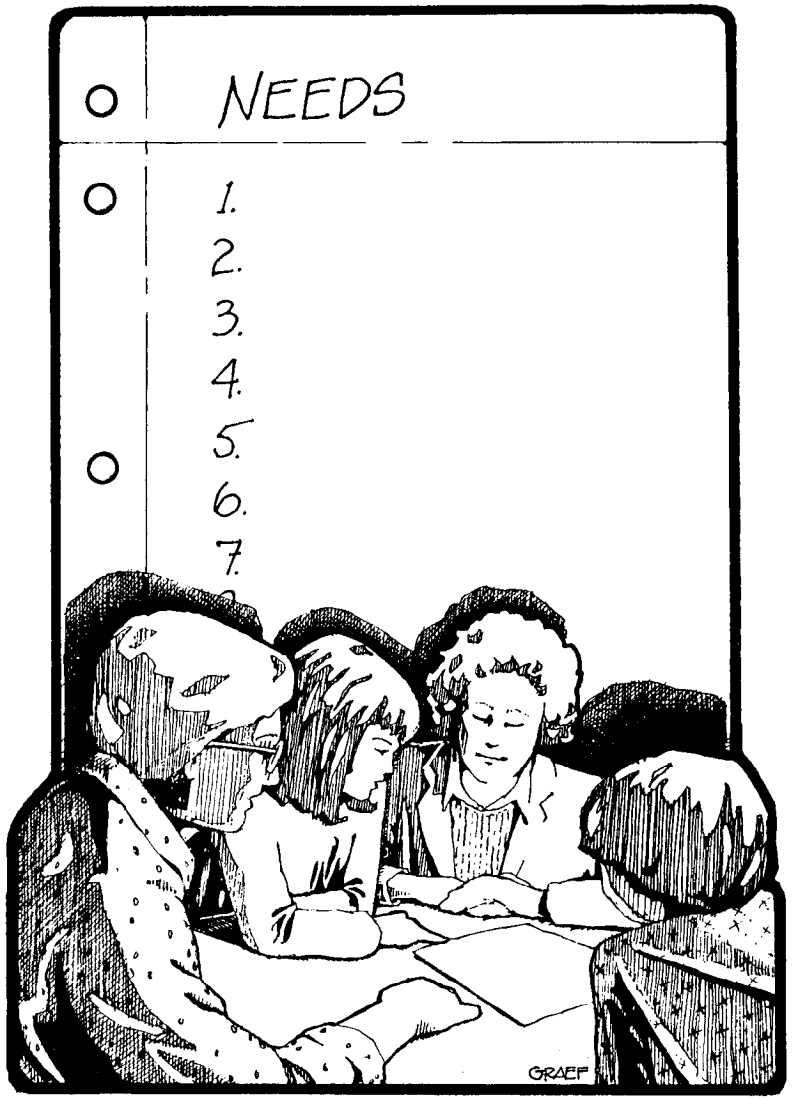
Now is the time to stop and think about how you want to use the space you plan to landscape. Do you want an outdoor living area? What will you use it for? Eating, cooking, sunbathing? A patio, deck or grassed area would be appropriate for these and other uses. Do you want a vegetable or fruit garden, outdoor play area, kennel, sports area or flower bed? You need to list all your activities and space requirements.

Do you want to attract birds and other wildlife? If so, plan to use lots of trees and shrubs, including fruiting ones, in your landscape design.

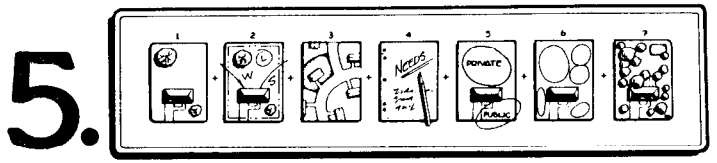
Do you want a low-maintenance landscape? If so, consider having a small lawn, placing trees, shrubs and ground covers in mulched planting beds and using plants that are well-adapted to your site conditions. Improperly designed plantings often require a lot of maintenance. Low-maintenance landscapes are discussed in more detail in another section of this publication.

If you plan any substantial landscape changes in the future – adding a swimming pool, tennis court or greenhouse, for example – reserve space now so you won't have to move plants or structures later.

Consider how much you can afford to spend on home landscaping. Many landscape architects and landscape nurserymen recommend investing about 10% of a house's value on the landscaping around it, although an acceptable landscape can be accomplished for much less. Once you've completed your plan, planting and construction can be spread over many years. To reduce costs, you can buy small plants and get do-it-yourself construction plans for patios, walks, decks and other structures. Even though your budget may limit your landscaping activities now, consider everything you want to accomplish eventually in your present landscape planning.



Step 5. Plan Outdoor “Use” Areas



The location and design of outdoor use areas will depend on family needs and preferences. The particular uses planned and amount of space available will determine use area size. Consider relationships between indoor and outdoor activities. You’ll want to keep areas near bedrooms quiet, while locating noisy outside areas near the kitchen, or perhaps away from the house if space permits.

Two general areas should be part of any home landscape design – public and private areas.

The **public** area usually includes the front yard, driveway, sidewalks and entrance to the house. On a corner lot, the public area may also extend into the side or backyard areas.

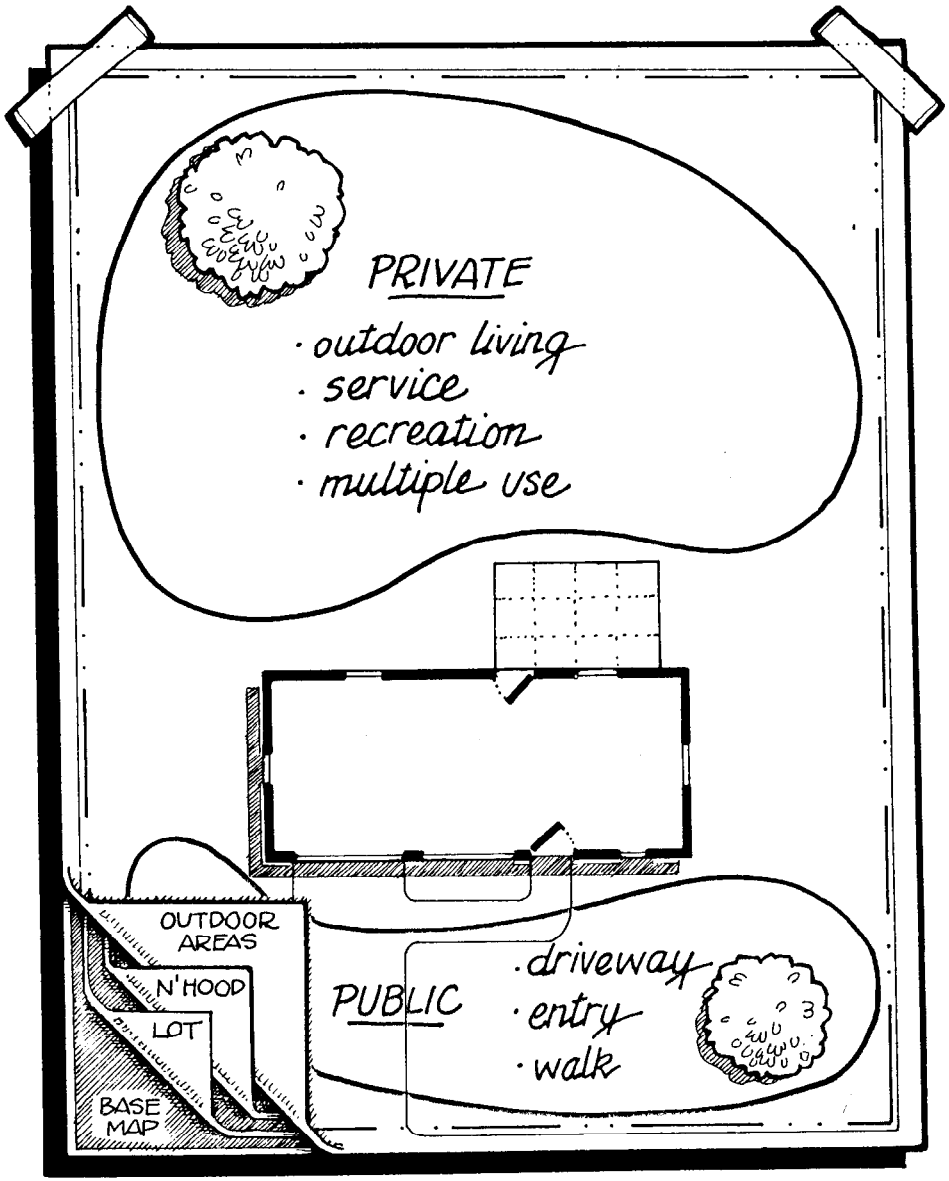
The entrance and front yard are the most public parts of most peoples’ yards. You can design the entire front yard for public viewing or – because of small lot size or a need for privacy – enclose parts of it with plants, fencing or both. Remember that your entrance and front yard contribute to overall neighborhood appearance – trees, shrubs, flowers, lawns, fences and other landscape structures should fit in with the neighborhood’s character.

Driveways and sidewalks link your home to neighborhood streets. Consider safety, topography and lot character when locating them. Keep grades as gentle as possible and make as few road cuts as possible. Remember the need for snow removal and landscape maintenance. Keep in mind how you want visitors to move from your parking area to the main entrance.

The **private** area of your yard or lot consists of living, service, recreation and multiple-use areas, depending on the needs you identified earlier.

An outdoor living area may include such features as terrace, deck, patio, screened porch and grassed areas for outdoor cooking, sunbathing, entertaining and just relaxing. Try to estimate the number of people who might use the area at one time so you can design it accordingly

Many homeowners like to have a service area for such things as vegetable and fruit gardens and wood and garbage storage. Choose these areas carefully. Vegetable gardens and many flowers need full sunlight and suitable soil. Wood and garbage storage areas should be accessible, but out of view.



You may want outdoor recreation areas for lawn games, swimming pool, tennis court, greenhouse or other purposes. Lot size, family needs and finances will determine how much space you can devote to outdoor recreation.

In many yards, space is limited. You may need to use the same area for several activities. Multiple-use areas may serve as living, recreation, and service areas at appropriate times.

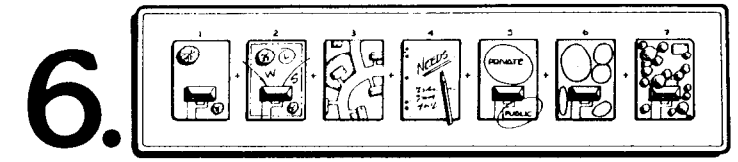
Step 6. Make Use Area Sketches

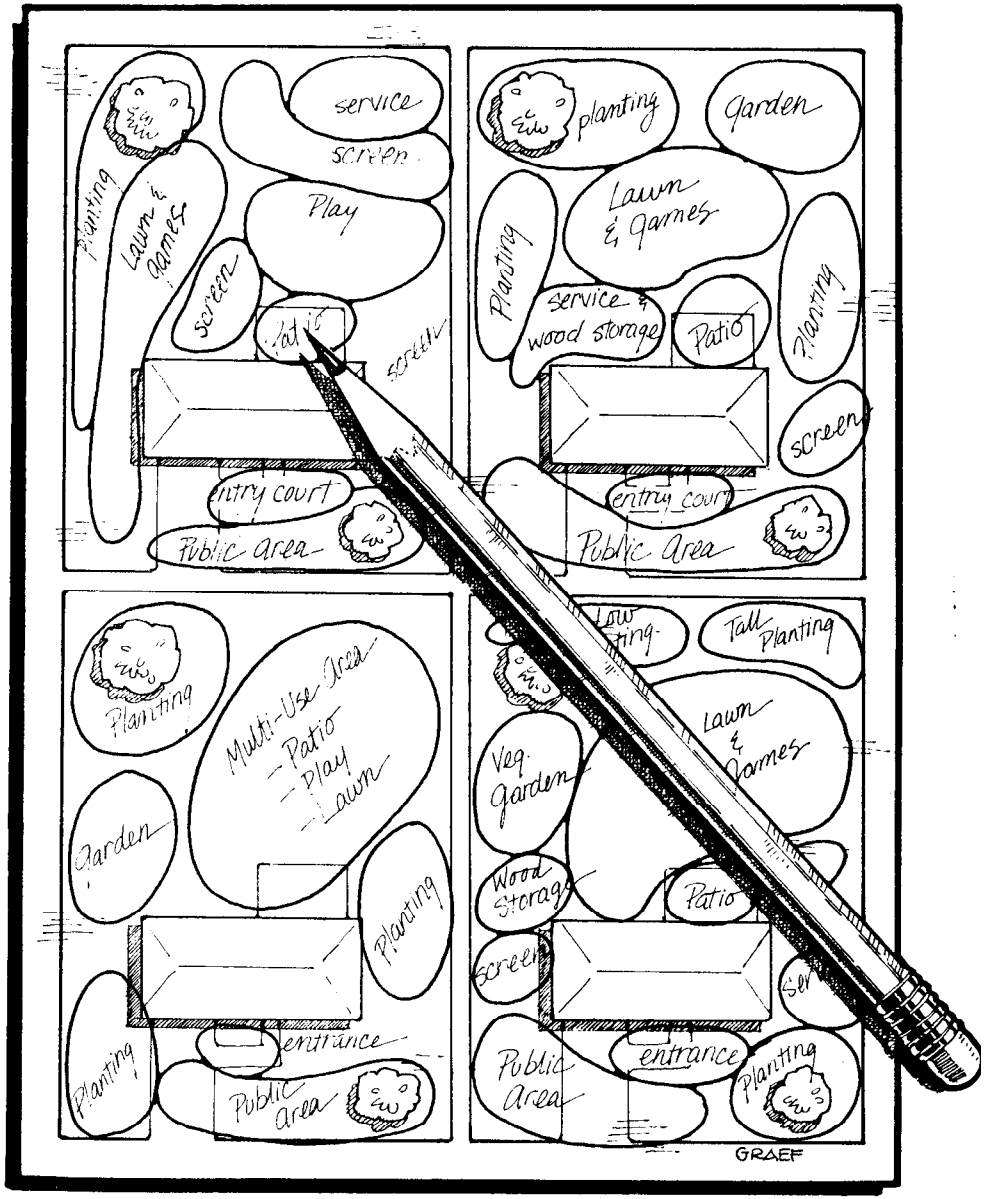
Now, after the necessary analyses (Steps 1-5), it's back to the drawing board! With tracing paper on top of your base and lot analysis maps, make a number of alternative general use sketches, fitting the use areas together in ways that take into account site features and family needs. Use circles, ovals and rectangles to locate specific spaces within your public and private areas. Keep the sketches that seem to suit your lot and family needs. Discard those that do not.

While making your sketches, consider these questions: Does the existing vegetation that you wanted to keep still fit into your plans? Is the slope of your property appropriate for your proposed outdoor use areas? Do your use areas make the most effective use of sunlight? After answering these questions, you may want to discard some use area arrangements and consider alternatives.

Grassed or hard-surfaced travel routes must be planned to provide convenient movement between different use areas. Indicate these routes with arrows on your plans.

So far, you have been collecting and combining information about your homesite and your needs. To give specific shape to the general use areas and to complete your landscape design (Step 7) you will need some understanding of design and composition principles. The next two sections give an overview of these principles.

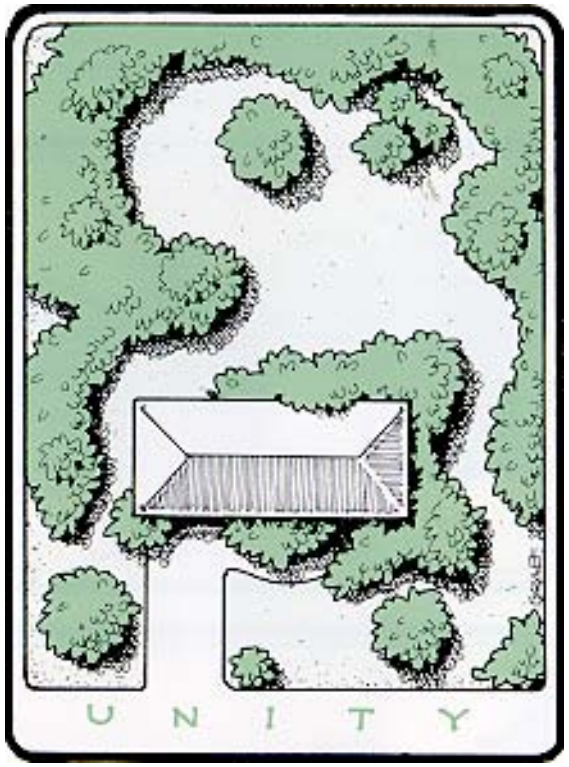


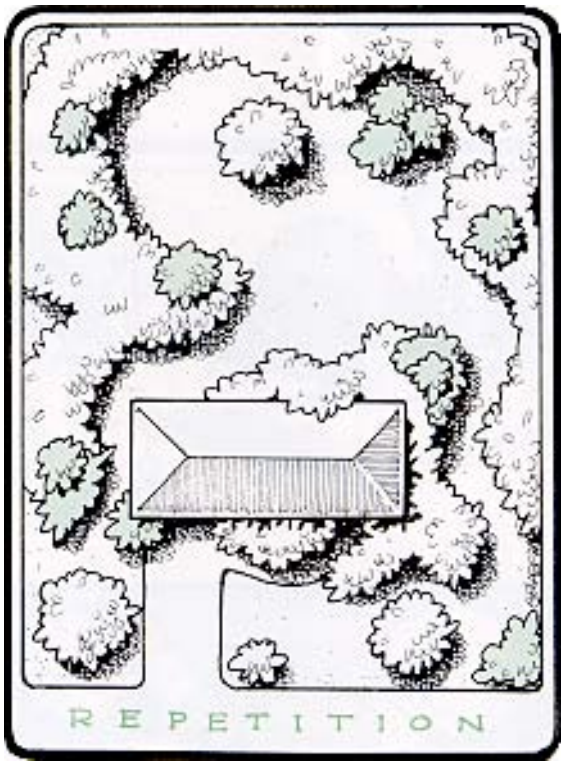


Landscape Design Principles

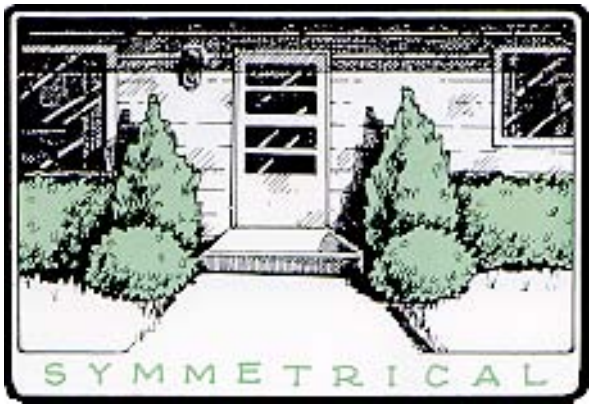
Home landscape designs vary according to family needs and preferences, but successful designs have certain underlying principles in common.

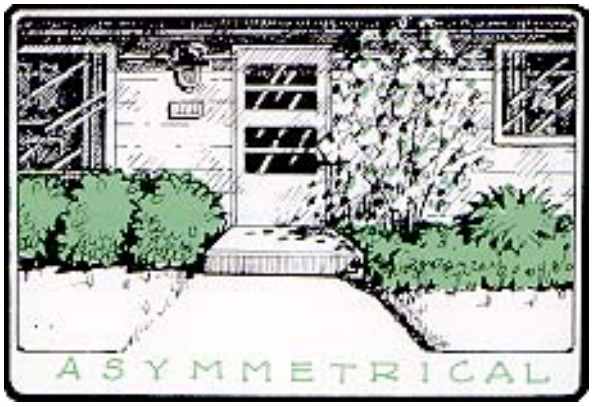
A landscape has **unity** when its predominant features have some visual characteristics in common. For example, plants with similar forms, colors and textures can create unity, both on your lot and in your neighborhood. This is also true of lawns and paving materials. Repeating a design pattern, color or texture in several different locations helps create unity.





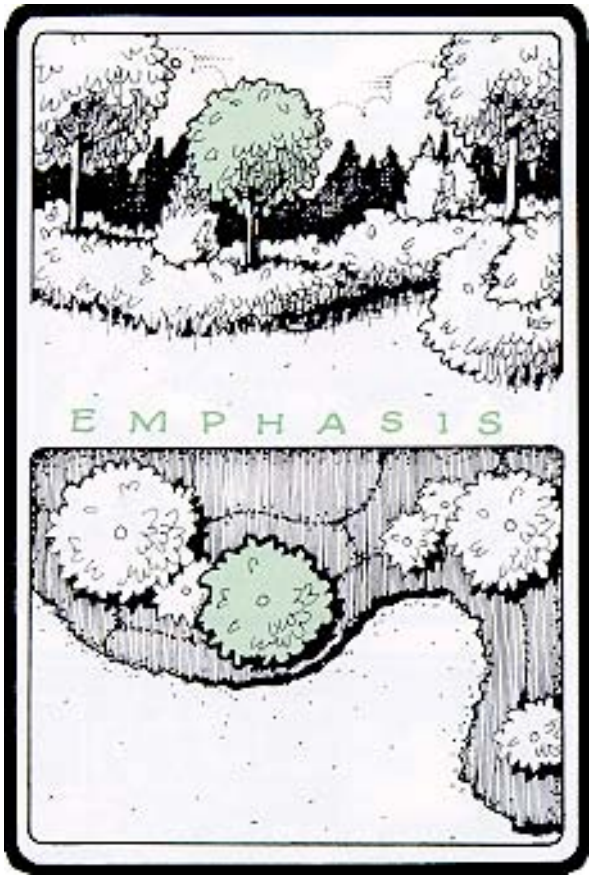
Plants and landscape structures of similar visual importance help create **balance** in a landscape design. With color, form, texture, size and other features, you can direct attention to several areas of the yard. Balance may be symmetrical ("formal"), in which each side of the yard is similar in pattern, or asymmetrical ("informal"), in which each side attracts the same attention even though objects and spacing are not repeated.



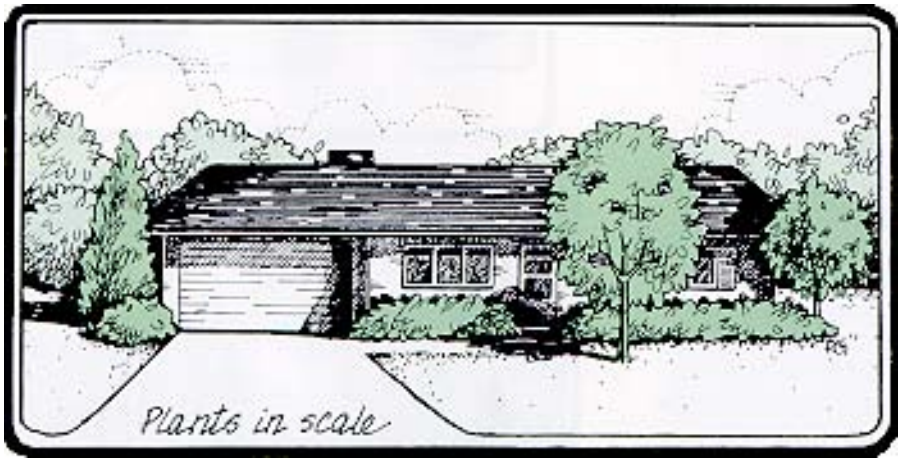


Accent areas or focal points to which attention is drawn create **emphasis** and keep a design's unity and balance from becoming monotonous. A single contrast in color, texture, form or height – such as provided by a bench, tree, pool, or flower bed – can provide emphasis.

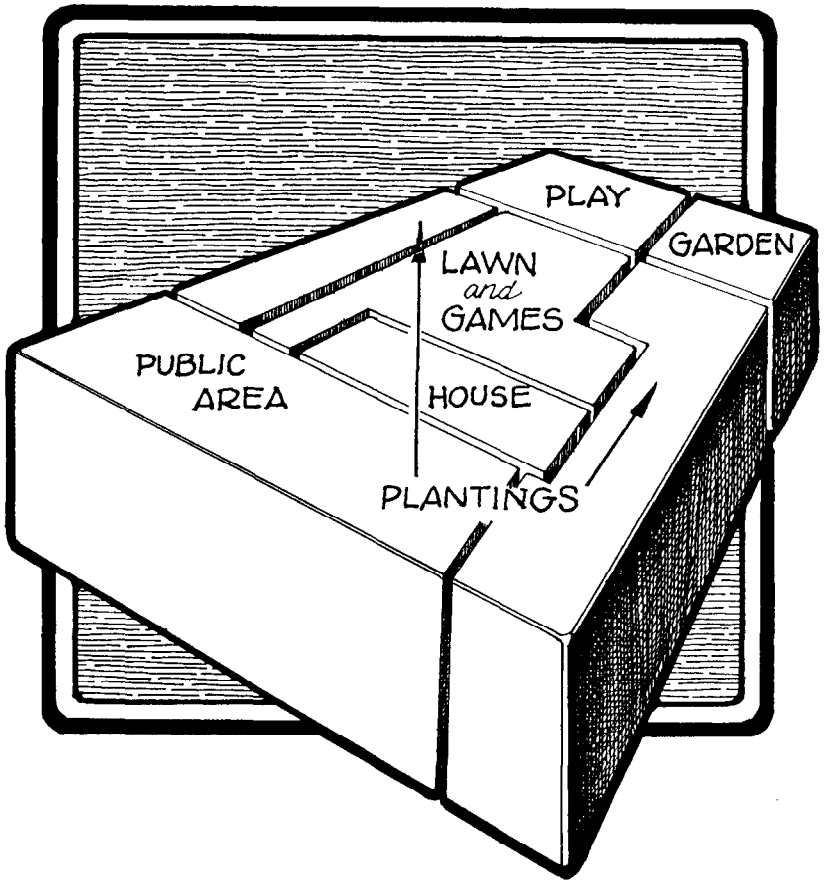
Scale refers to the size relationships among plants, structures and open spaces. A 4-foot-high shrub with a 4-foot spread may be too large – and therefore out of scale – in front of low windows. Next to a high-rise building, however, the same shrub would be out of scale because it is too small. In some home landscape situations, group plantings will compensate for plants with too-little spread.

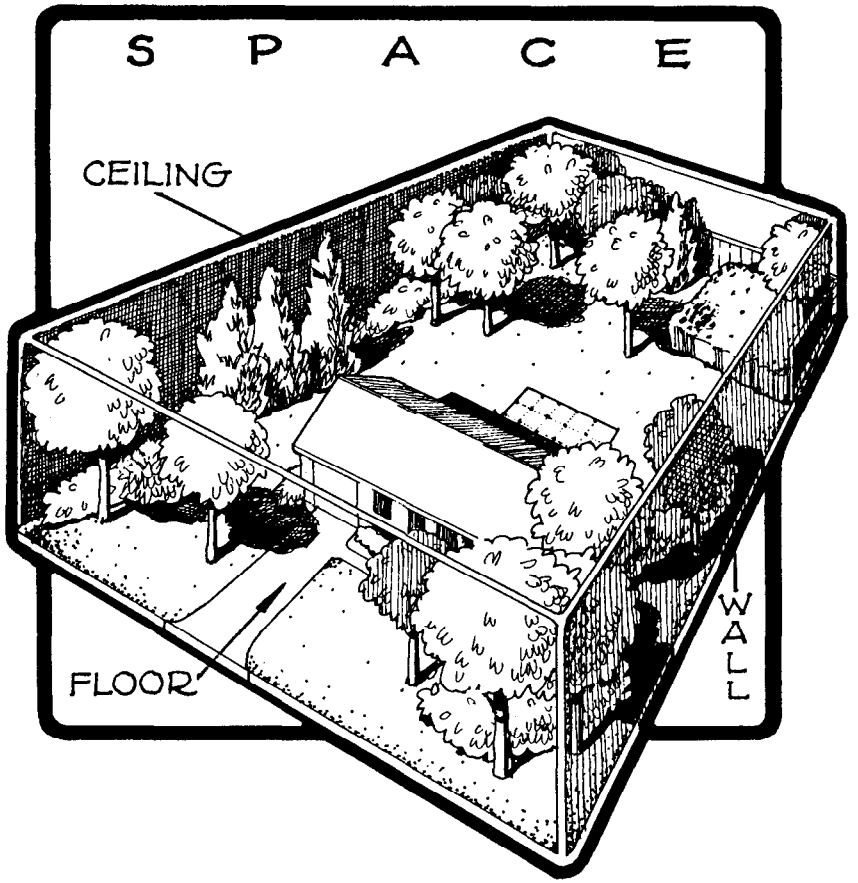






Space. Your entire lot can be considered a block of space with dimensions of length, width and height. Plants, fences and buildings are used to divide the lot into smaller living spaces analogous to the rooms of your house. These outdoor "rooms" should have separate identities and should meet your use area needs. The "rooms" should have openings that direct movement from one to another.



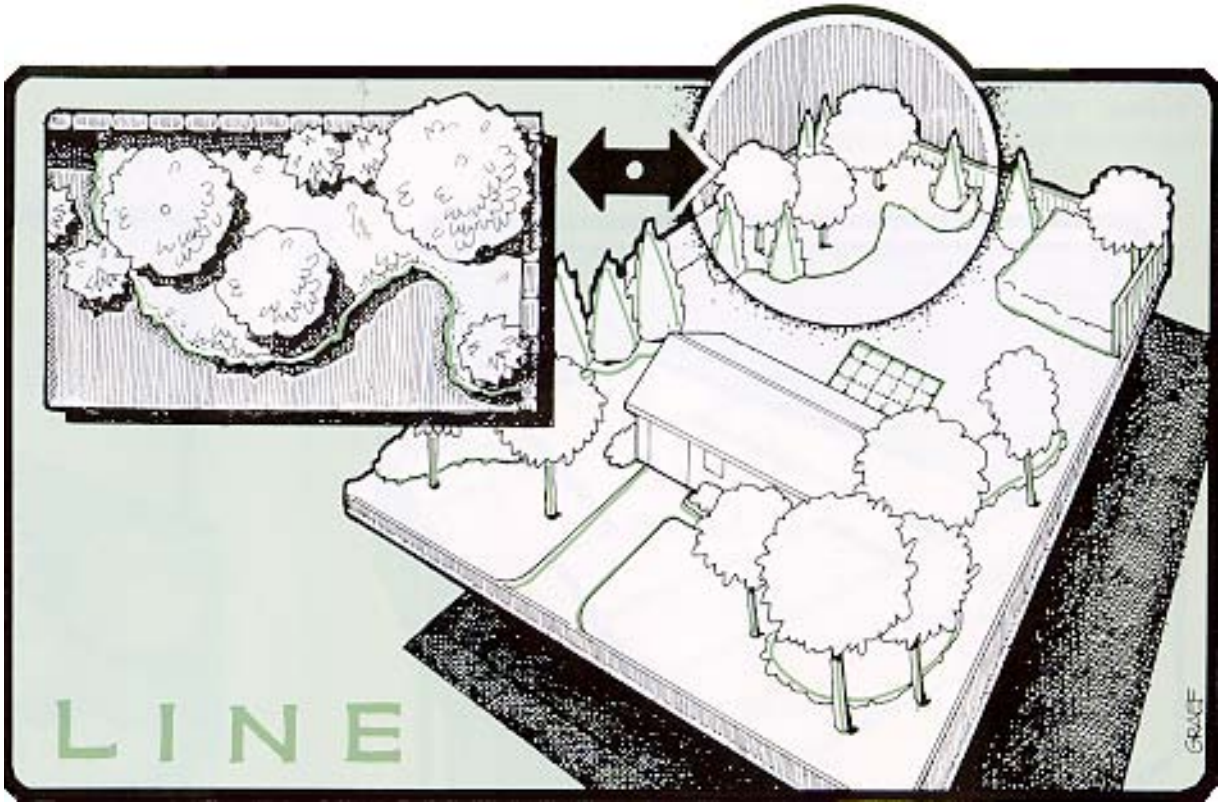


Lines may be straight or curved. Landscape designers frequently lay out patios, decks and planting beds using straight lines that extend – or parallel – house and lot lines. Equally successful – and more naturalistic –- designs can be created with curved lines. Straight and curved lines can be combined in a design, but it is difficult for the beginning designer to do this successfully.

These design principles will help you give specific shapes to the areas you identified in your general use sketches. But you can't design a landscape based only on placement and size of plants and structures – the main components of home landscape. You must also select the appropriate plants and construction materials.

In other words, from design principles you may arrive at the proper location and shape for a planting bed. But you must also decide what plants to put in the bed. In the same way, you have to decide what to surface a patio with as well as where and how big the patio should be.

Both plants and building materials can be selected for their form, texture and color. You will need to keep these elements of landscape composition in mind as you proceed toward your final landscape design. We discuss them further in later sections of this publication.



Selecting Landscape Plants

There are three things to consider in selecting plants. They are, in the order you should consider them: plant hardiness, site conditions and suitability for your landscape design.

Wisconsin is divided into hardiness zones based on lowest winter temperatures. Many plants cannot survive Wisconsin winters.

All plants require a certain set of growing conditions. The conditions your site offers will determine what plants will grow well there.

Soils vary greatly in acidity, drainage, and fertility. Sandy soils are usually well drained, while clay soils may become water logged. Few plants do well in both situations. Use the soil information from your lot or farmstead analysis in selecting plants. It's better to select plants for your soil than to try to change the soil.

Plants vary in their **sunlight** requirements. For example, the Japanese yew does well in shade, but junipers need full sunlight to grow well and look their best. As you evaluate alternative landscape designs, consider shade patterns created by buildings and existing plants.

Some evergreen trees and shrubs will not tolerate the drying effect of winter winds. On the other hand, most hardy deciduous plants (those that drop their leaves in fall) will tolerate full exposure.

Topography. Some plants have adapted to cooler northern slopes, while others do better with hot, dry, south-facing exposure.

Be aware of possible air and soil **pollution** when selecting plants. De-icing salt damages many plants, either as a soil contaminant or as a spray created by traffic or snow plowing. Pollutants from industries and automobiles, such as sulfur dioxide, ozone and fluoride, also damage plants.

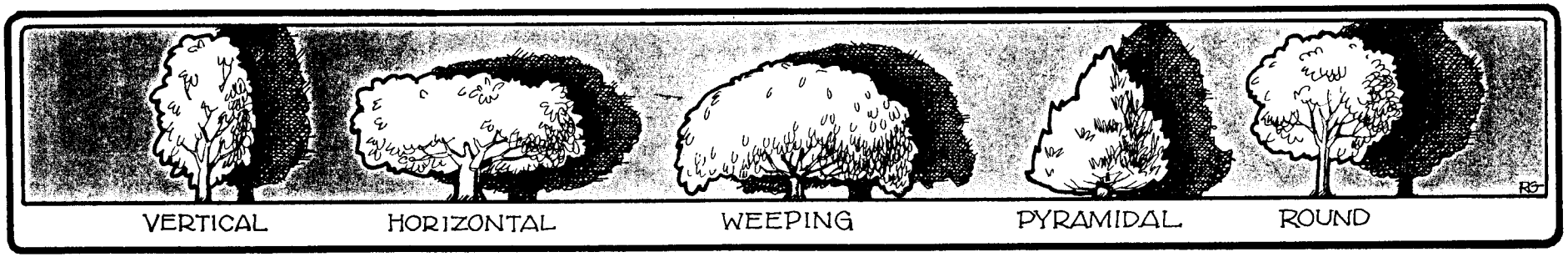
You must select plants that will grow well under your conditions or you'll have trouble keeping them healthy from the outset.

Extension publications A2865, "A Guide to Selecting Landscape Plants in Wisconsin," and A2970, "Salt Injury to Landscape Plants," contain more information on these subjects.

Design considerations

Plants have different **forms,** or growth habits. Basic forms and their common uses are:

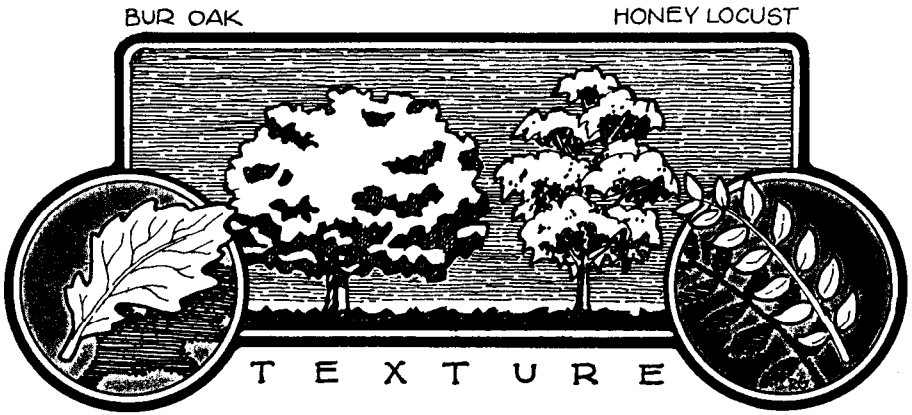
–vertical – usually used sparingly as accents or to provide height
–horizontal – used to provide width and to "attach" structures to the ground
–weeping – usually used only as accents
–pyramidal – used as accents or combined with rounded and horizontal plants
–rounded – used to create large masses, borders or enclosures

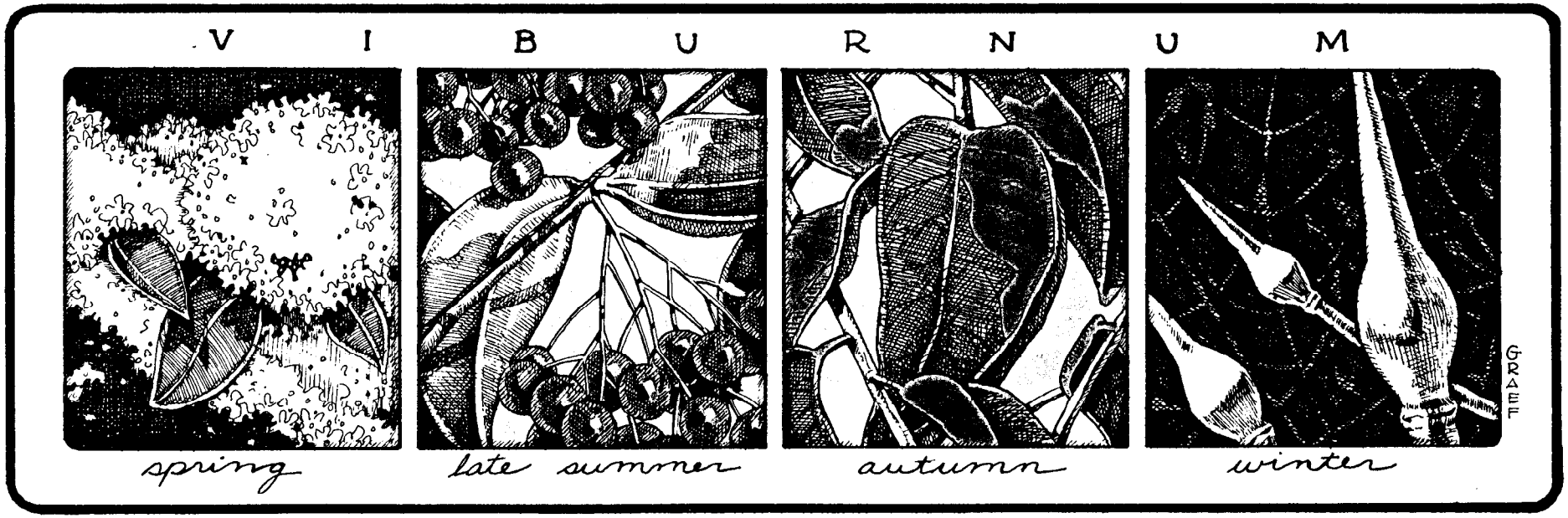


The size of a plant's leaves, twigs and branches determines its **texture.** Fine-textured plants have small leaves and twigs, coarse-textured ones have large, and medium-textured ones in between. You may want to select plants of all three textures. Often, the size of a landscape space will determine what texture is appropriate – a small space will seem larger with fine-textured plants than with coarse-textured ones, for example.

The dominance of one **color** helps provide harmony in a home landscape as well as throughout an entire neighborhood. For most people, green foliage creates a restful landscape. But you may want to select plants with particular fruit, bark and fall leaf colors to serve as accents as the seasons change.

You may want to consider using some native plants in your design. Plants native to Wisconsin are just as beautiful as non-native ones and are often better adapted to our growing conditions. Honeysuckle, buckthorn and other ornamentals that have escaped to the wild have actually forced some native plants from natural plant communities. Certain varieties of buckthorn are disease carriers for a rust that affects oats.





Trees

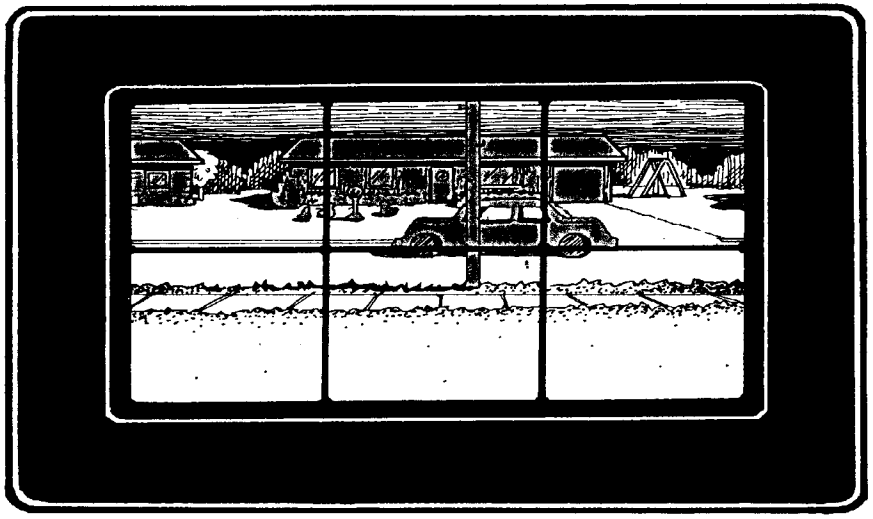
Trees – both deciduous and evergreen – help put a house and its surrounding into proper scale. They should be planted where they will enhance the overall appearance of your home's setting as well as provide shade in summer and wind protection in winter. Frequently, trees are used to frame a good view or screen a poor one.

A variety of small to medium-sized trees may be used as accent plants. You can base your choice on a combination of visual characteristics, including foliage and flower color, fruit, bark, fragrance and texture. Fruit trees may be used as accent plants, but remember that they can be messy and require regular spraying for insect and disease control.

Consider planting several kinds of trees to minimize the risks of insects and diseases. But don't overdo it – too many kinds of trees may deprive your landscape of unity. A compromise – planting several representatives of several different types – will provide both a measure of insect and disease resistance and design unity.

Plant individual shade trees 30-40 feet apart. Or, for a more natural, forest-like landscape, vary tree spacing from 5-50 feet. To obtain the best shade patterns and to avoid foundation damage, plant trees 15-25 feet from the house. Irregular tree placement creates an informal setting.

In urban areas, check with municipal officials before planting trees in the terrace between street and sidewalks.





Shrubs

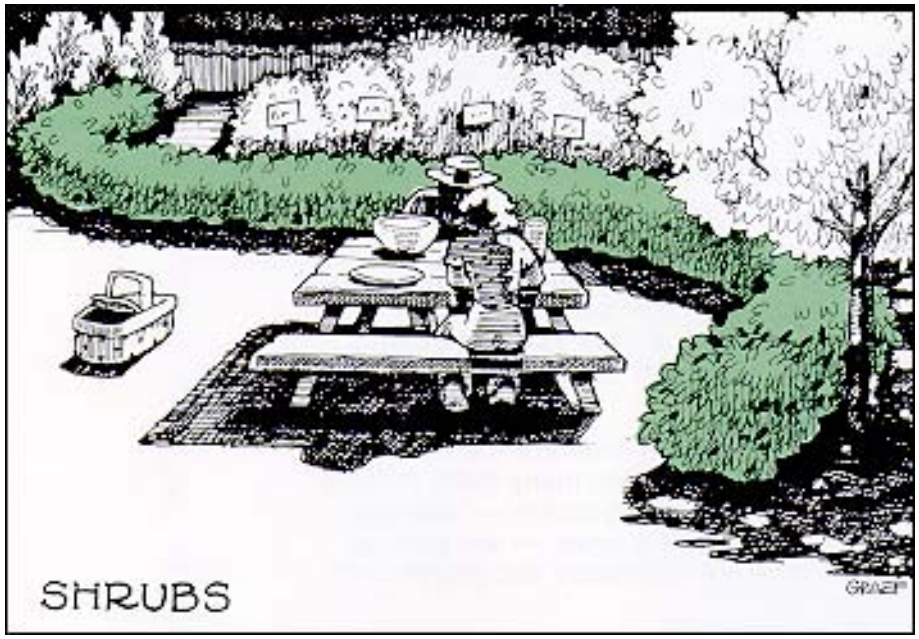
Deciduous and evergreen shrubs are an important part of most home landscapes. Planted in groups, they create screens and barriers or serve as foundation plantings or understory plants beneath trees. Although most shrubs work best in groups, they may also be used as accents – accent shrubs can help lead visitors to your entrance, for example.

Masses of shrubs effectively delineate different use areas in the yard, much as walls delineate the rooms of a house. A heavy planting of shrubs at house corners softens the transition between vertical walls and horizontal ground lines.

Foundation plantings should enhance your overall landscape design. Generally, it's not good design practice to surround a house completely with foundation plants unless you need to screen an unsightly foundation. For under windows and eaves, select foundation plants that will not be too tall when mature.

Taller plants may shade out understory plants, so select shade-tolerant shrubs for use as understory plants.

You can create seasonal variety with combination plantings of evergreen and deciduous shrubs. Remember that landscapes have a more unified appearance when green-foliaged plants predominate. Shrubs with red, purple, yellow or silver summer foliage can become unintended "focal points" and detract from your landscape design. It's better to select accent shrubs based on flower, fruit, bark and fall leaf color. You can unify your landscape by planting the same kinds of shrubs in several different locations.





Avoid planting shrubs too close together – size at maturity should determine spacing. Don't give in to the desire to achieve the mass effect of a group planting too rapidly. A mature landscape cannot be created in one growing season. It will require at least three years, perhaps five, before a group planting achieves its intended effect.

Tall shrubs are usually planted 5-7 feet apart, medium shrubs 3-5 feet apart and low shrubs 2-3 feet apart. Place shrubs slightly more than one-half their ultimate spread away from the foundation so they can attain their natural forms.

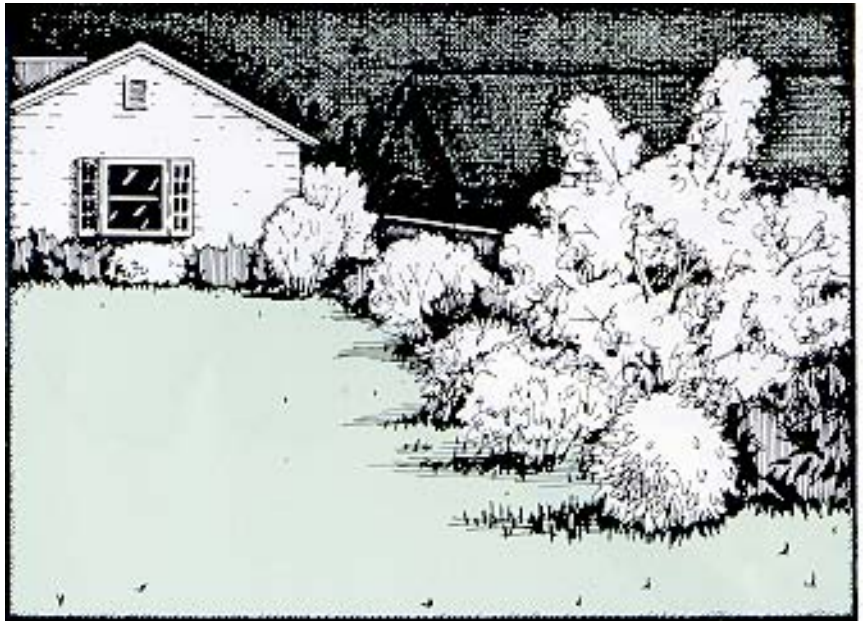
Ground Covers, Vines and Flowers

Ground covers, vines and flowers complement most home landscape designs.

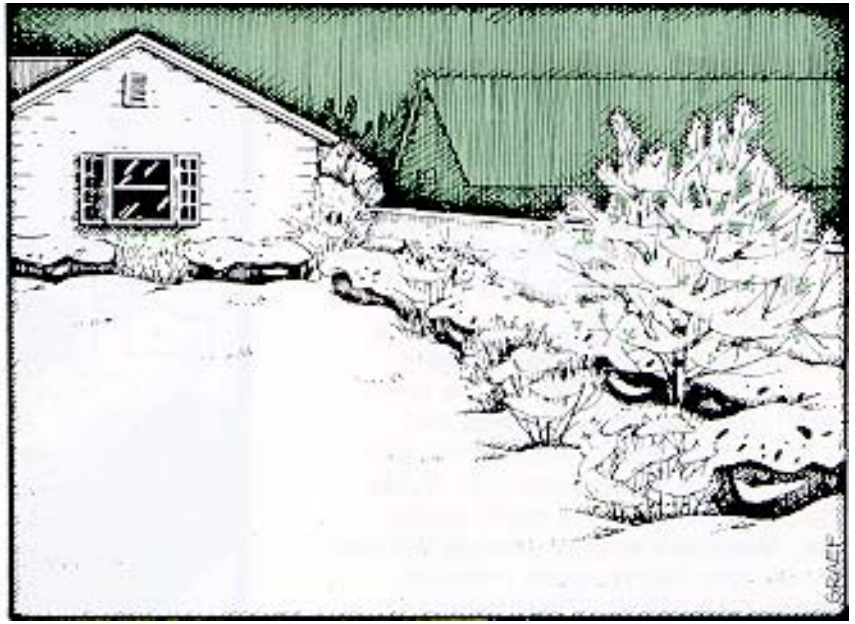
Ground covers help unify tree and shrub plantings and provide a contrast between lawn and planting beds. Mass plantings of perennial ground covers reduce landscape maintenance.

Vines soften the texture of brick and stone as well as shade house walls. They will cover chain link fences and help provide screening where space for trees and shrubs is limited.





S U M M E R



W I N T E R

Flowers add color to your yard. They can be planted in beds and borders, in front of shrub masses and to fill in open areas while shrubs are growing. Flowers look best against a simple background, such as a fence or shrub planting, so they're not recommended for the middle of a lawn. Both perennial and annual flowers require a lot of maintenance.

Lawns

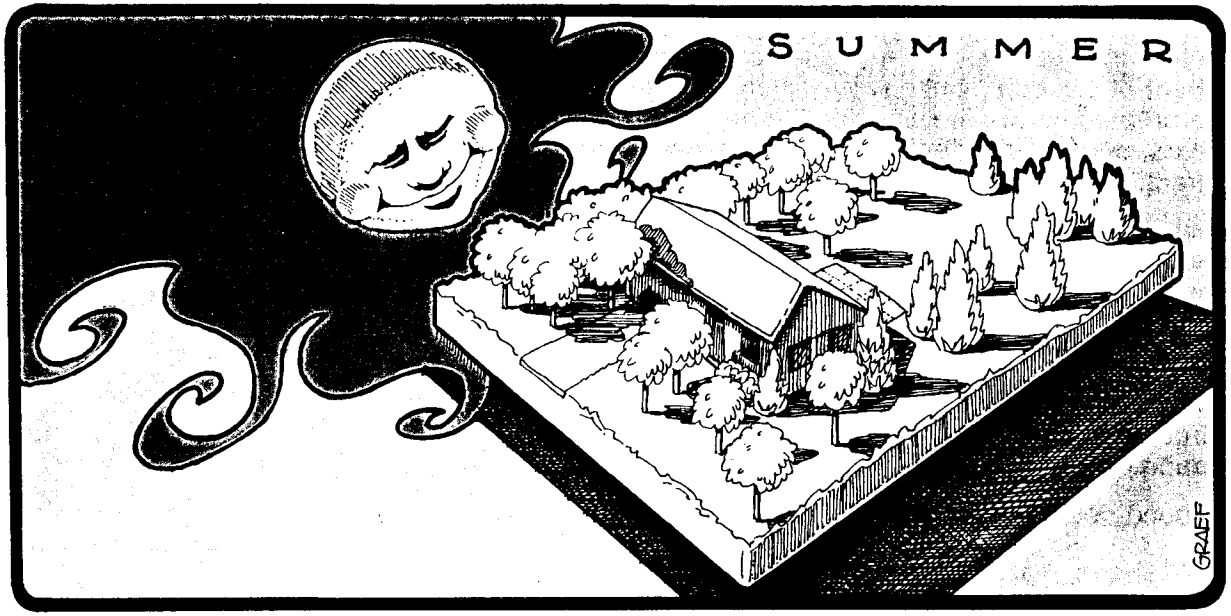
A lawn adds unity to a landscape design by linking together the various "rooms" of a landscape. It is also a good ground cover for recreation and service areas and for travel routes between use areas.

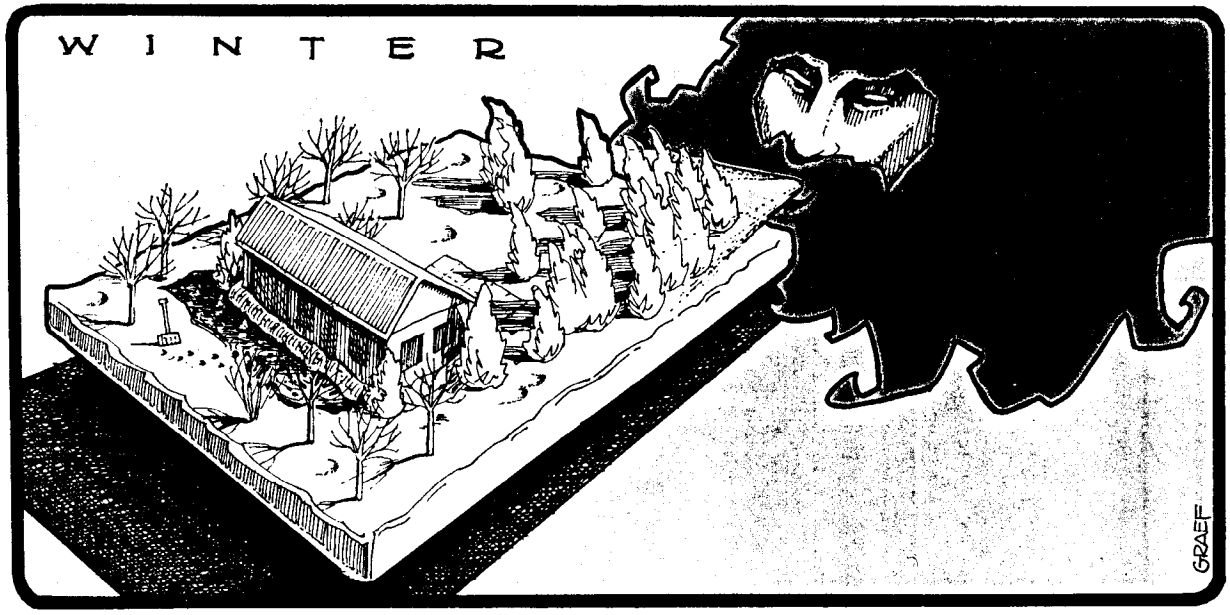
Publications on planting and maintaining lawns are available at county Extension offices.

Planting for Energy Conservation

Proper selection and placement of plants can reduce home energy consumption. Deciduous trees planted 15-25 feet away from the house on the east, south and west sides shade the roof and walls in summer, reducing surface temperatures. After the trees have dropped their leaves in fall, winter sunlight can reach the house to provide passive solar heating.

Windbreaks, mainly evergreen plantings, located four to six times their ultimate height away from the house on the north and west sides can reduce winds and winter fuel consumption. Foundation plantings also reduce winter heat loss. Vines can shade and cool house walls during summer. Maximum energy savings will not occur until your plants reach maturity. Publication G81N1178; "Designing an Energy – Efficient Home Landscaping" contains more details.





Landscape Structures

Most libraries, book stores and garden center offer a variety of publications that contain detailed construction plans and material suggestions for landscape structures. We discuss only the more common structures in this publication.

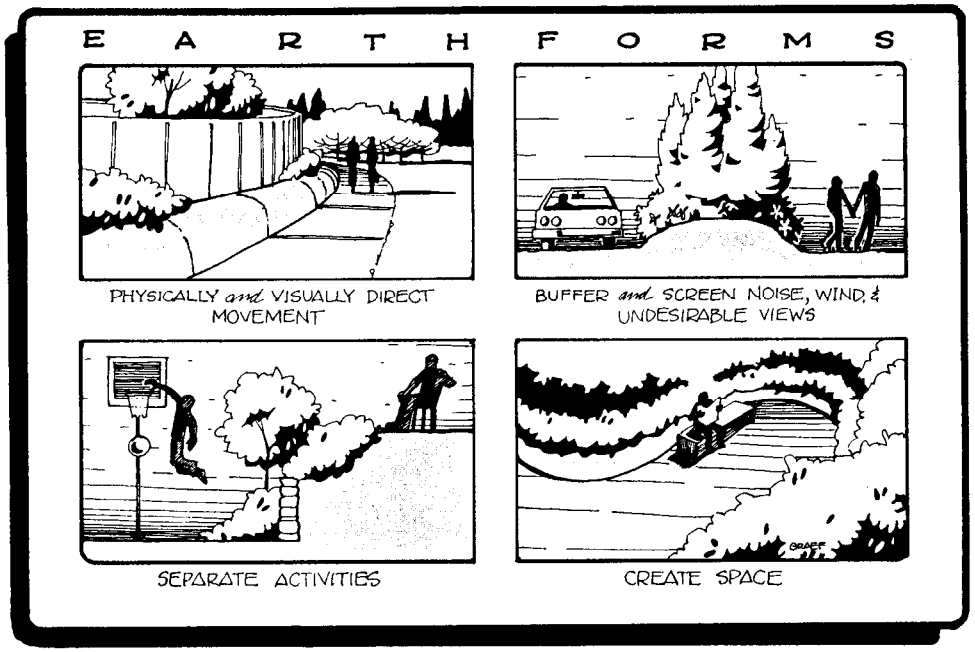
Grading

If your homesite is already graded and even partially landscaped, you probably won't want to change its contours. But if the final grading has not been done, you may be able to create the topography most appropriate for your landscape design.

Actually, the best time to think about changing a homesite's topography is before building begins. This is also the best time to decide whether shade trees and other plants already there should be saved. Mature trees and shrubs add thousands of dollars of value to residential properties.

If you want to keep existing plants in your landscape design, they should be protected before constuction begins. Construction equipment can damage and kill trees by compacting soil in their root zones. A simple fence erected just beyond the branch spread of a tree will protect both roots and trunk from damage.

If you change the grade around an established tree, you must avoid changing the amount of air, water and soil nutrients reaching it. See Extension publication A3072, "Preserving Trees During Construction", for details on how to accomplish this.



During rough grading, the topsoil should be stockpiled away from the immediate construction site. To protect this valuable soil from erosion for a short time, spread weed-free straw or marsh hay over it. If the topsoil is to be stockpiled for more than one season, seed the pile with annual rye grass, oats or another annual plant. When construction is completed, the topsoil should be spread evenly over the lot. A 4-6 inch layer is ideal, although two inches may be adequate if it is incorporated into the top six inches of soil.

Mounds, berms and changes in ground contour great enough to require steps or retaining walls help create an interesting landscape. But they should perform a specific function, such as outlining specific use areas or other lawn spaces, buffering noise or screening unwanted views. Mounds should blend into the surrounding topography and look natural.

Your ground elevation must match your neighbors' at lot lines. You can accomplish this with gradual grading or retaining walls.

Driveways

The driveway is an integral part of a home's public areas, providing access for both vehicles and pedestrians. At most homes, it is where visitors arrive, mail is delivered, trash is picked up and children play. It should be wide enough to accommodate pedestrians and vehicles at the same time. If you have enough space, consider constructing a turn court and parking area to permit the unhampered – and safe – movement of vehicles.

For safety, the drive should meet the street at a right angle, and plants or structures must not hamper a driver's vision. If the drive has a steep grade, try to design a nearly level area near the garage and at the street intersection.

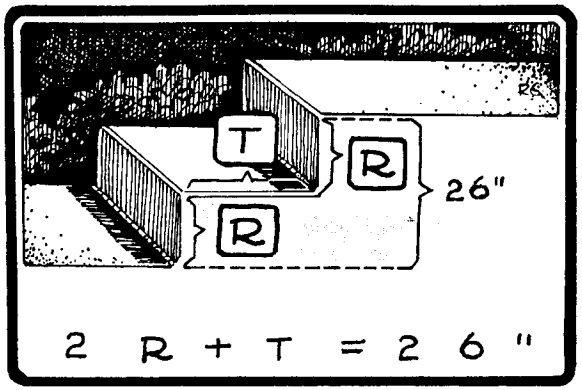
Driveways should have a slope of at least 1% (1 foot rise per 100 feet traveled) for proper drainage. But a slope of more than 10% will be hazardous in winter. Remember to provide space where snow can be placed in winter without damaging plants or structures.

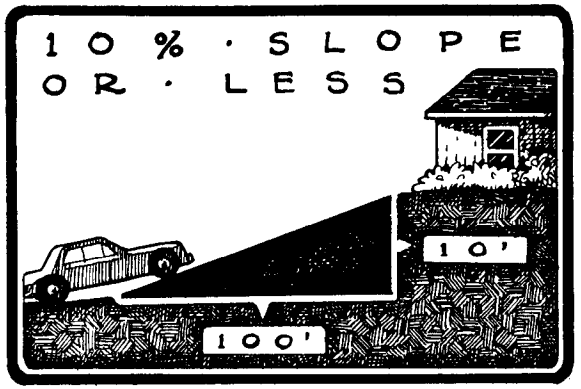
We recommend that homeowners seek professional help to make sure that unusually long driveways or those on steep grades fit harmoniously into the landscape.

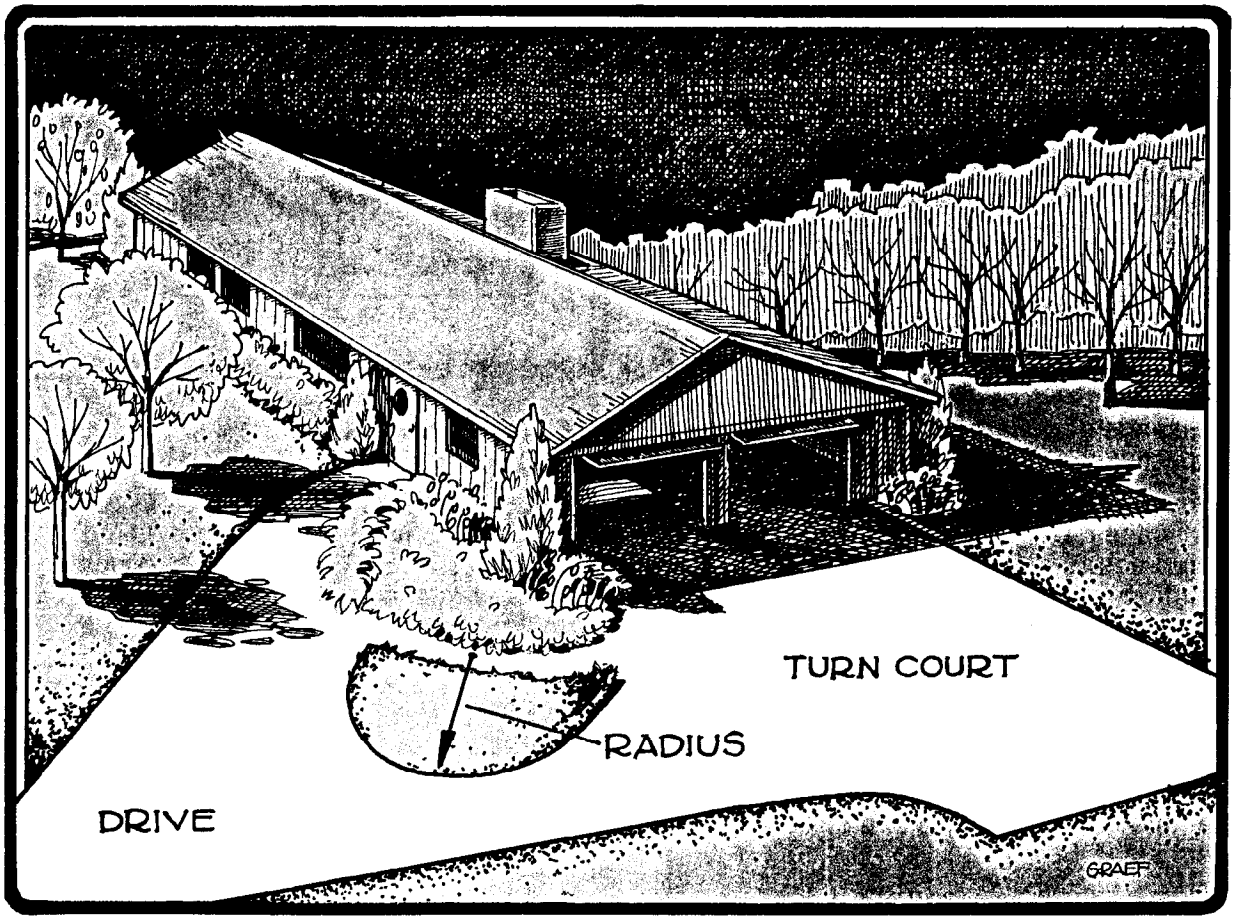
Walks

Most people find walks already in place when they move into a home. Typically, an entrance walk meets the driveway at a right angle and parallels the house to the front door. Unfortunately, in many cases the walk is too narrow for comfortable pedestrian use and too close to the house for proper plant growth.

An entrance walk should be at least 4 feet wide. A large house may require a 5-foot







walk for proper scale. If you have the opportunity to plan your entrance walk, leave at least 4 feet between it and the house. This will provide enough space for an entrance planting to accent the front door.

As for the driveway, plan the entrance walk for easy access and winter snow removal. A slope of 1-4% is ideal. For safety, the slope should be no more than 6%.

Steps

Where the ground slopes more than 6%, you will need to install steps to permit people to move from one level to another. No matter what the steps are constructed of, they should meet a long-established standard for safe and convenient outdoor steps: two risers (the riser is the vertical part of a step) plus one tread (the horizontal part) should have a combined measurement of 26 inches. The most common step dimensions are 5½-inch risers with 15-inch treads and 6-inch risers with 14-inch treads.

A pedestrian may not notice only one or two steps, so as a rule a set of steps should have at least three risers. If this isn't possible, use an eye-catching surface material or outdoor lighting to make the steps visible. Handrails make steps safer, especially in winter.

Decks and patios

If you want a deck or patio for outdoor living, plan for it carefully to make it useful in as many ways as possible.

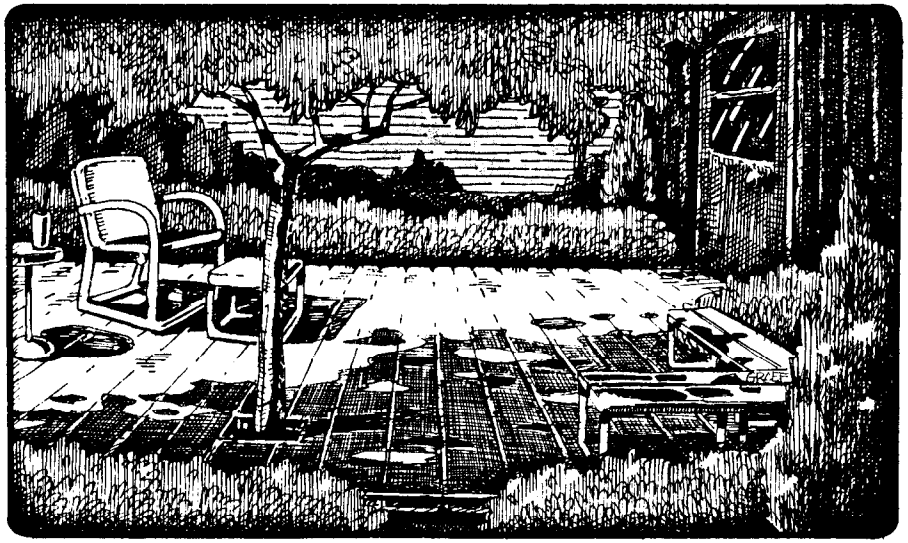
Location is one important consideration. A patio or deck should be convenient to the appropriate areas of your house. If you will use it mainly for sunbathing, you'll probably want it off the bedroom. If you plan to eat or entertain there, place it near the kitchen or family room. Of course, door locations may limit your placement alternatives. Other factors to consider are exposure to sunlight, summer winds, good views and privacy.

Patio size will depend on what you want to use the patio for, yard space available and family size. We recommend about 64 square feet of hard-surfaced patio space for every family member.

A patio should have a 1-2% slope away from the house so water will drain away from the house.

A deck can provide a level outdoor area over steep ground. It should appear to be an extension of the house. Its color and texture should make it harmonize with the house and surrounding landscape.

The architectural lines of your home; choice of construction materials and other aspects of your landscape-design will all influence the shape of a patio or deck.



D E C K



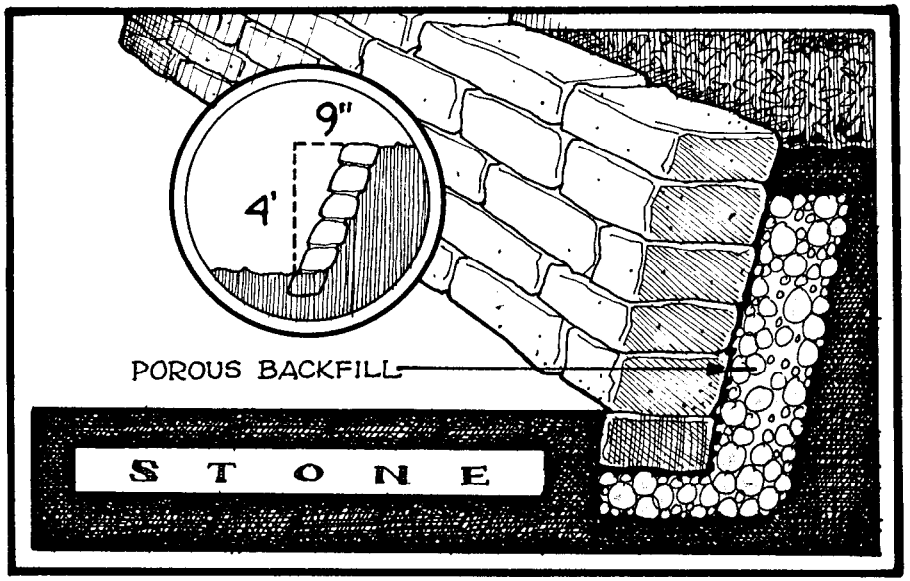
P A T I O

Retaining Walls

Retaining walls are used to make abrupt changes in elevation, provide privacy and delineate outdoor space. Stone, brick, wood ties, timbers and concrete are the most commonly used materials.

For steep grade changes, a series of low walls is usually better than one high one. The higher the wall, the more it must be reinforced to withstand the pressures created by freezing and thawing in winter.

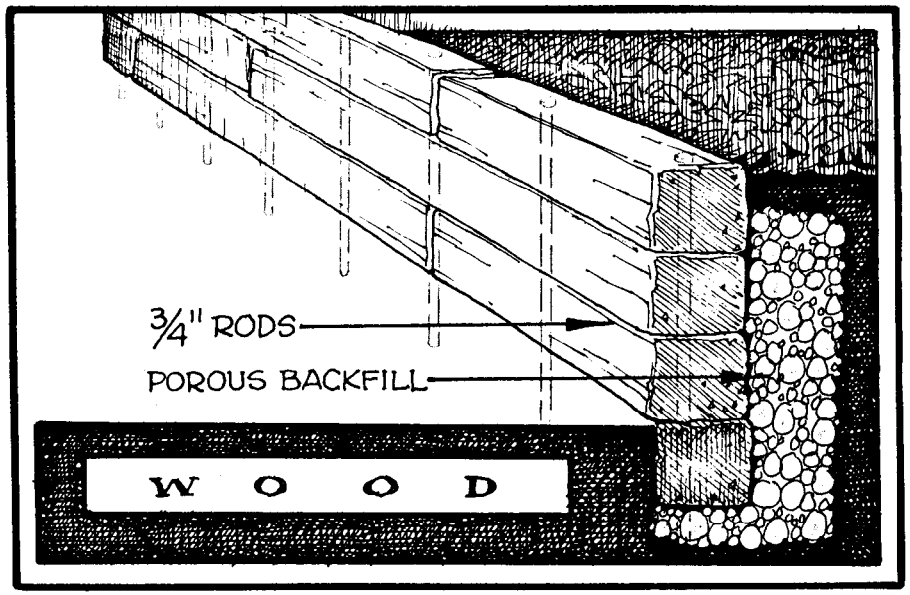
For both dry and mortared walls, careful planning and construction are essential. Consult detailed design books or seek professional assistance if you plan a retaining wall more than 4 feet high.



Fences

Fences, alone or in combination with mass plantings, provide privacy and enclosure in the home landscape. They also serve as windscreens, "poor-view" screens, accents, space dividers, sources of shade and backdrops for plants.

Fences may be constructed in a variety of styles and from many different materials. If you decide to build a fence, choose a style that complements your overall landscape design. Chain link fences, with or without plastic strips, rarely beautify a yard. Fences made of dark or neutral-colored natural materials usually do.



Lighting

Outdoor lighting can be included in your landscape design. Lighting walks and entrances makes them safer, especially during dark and slippery winter months. Soft overhead lighting extends the useful hours of patios and decks. With lights, you can highlight particular plants or structures. Low landscape lighting – no more than 3 feet from the ground – can help unify your entire landscape in the evening.

Low-Maintenance Landscapes

All plants and structures require some maintenance, but you have some choice as to whether your landscape will require a lot of maintenance or a little. Many homeowners enjoy lawn and garden work and knowlingly choose plants and structures that require a lot of maintenance. Others want an attractive and functional landscape, but would rather not spend evenings and weekends weeding, mowing, watering, edging and pruning. If you are in the latter category, you should work toward a low-maintenance landscape.

Mulched planting beds usually require less maintenance than the same area of properly maintained lawn. Two to four inches of shredded bark, wood chips, ground corncobs or similar organic materials control weeds, retain soil moisture and moderate soil temperatures, while blending into the landscape.

We don't recommend placing a plastic sheet under organic mulches, but crushed stone, marble chips and washed gravel must be underlain with black plastic for effective weed control. These inorganic mulches can reduce aeration of heavy or poorly drained soils (while providing only limited moisture retention), and they sometimes reflect enough sunlight to damage plants. Crushed stone and marble chips introduce exotic colors which violate basic design principles in many situations.

For those areas where a lawn is necessary, use a mulching mower to avoid having to rake leaf clippings and to reduce fertilizer needs (by returning plant nutrients to the soil).

Edging around planting beds reduces maintenance time – by separating the beds from the lawn – and helps unify a landscape design. Select an edging material with texture and color that complement the house and other landscape structures – stone, wood, brick, steel and plastic are all available.

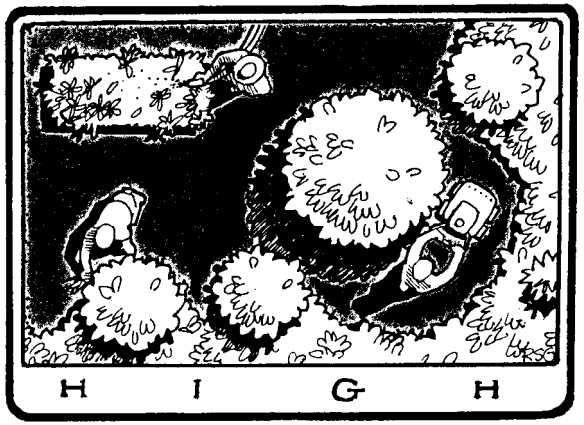
A perennial ground cover under trees and shrubs also reduces maintenance requirements. Most ground covers grow well in an organic mulch and, if planted at the right density, can even be used in place of a mulch.

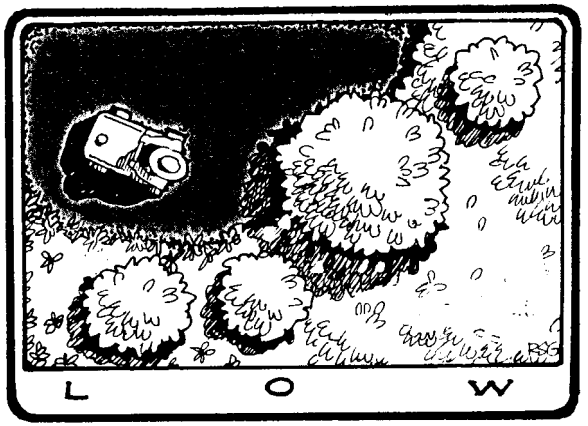
Use well-adapted plants that will require minimal maintenance. It takes a lot of time to maintain unnatural plant forms like topiaries, espaliers and pollards.

Space plants properly during the initial planting. If you overplant, you will have extra pruning, trimming and thinning. If you underplant, you may have to fill in with more plants.

Planting flowers in containers and small planting beds makes annual planting and removal easier.

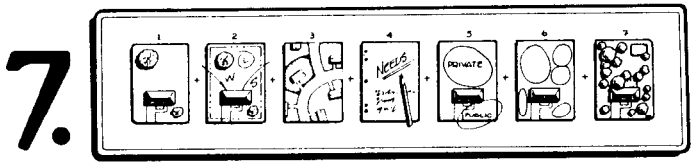
A "natural" landscape usually requires less maintenance than most conventional ones.





Finishing Your Landscape Design

Step 7. Putting It All Together



Once again, it's time to go back to the drawing board. Your last efforts there should have produced a number of alternative use area sketches. Now you will give exact shapes to the use areas you want and decide what plants and structures will create those shapes and a pleasing overall landscape design.

If it has been some time since you made the general use sketches you may want to retrace the steps that led up to them, by reviewing the first three sections of this publication. To complete a successful design, you need to have a grasp of lot, house, and neighborhood characteristics as well as general design principles.

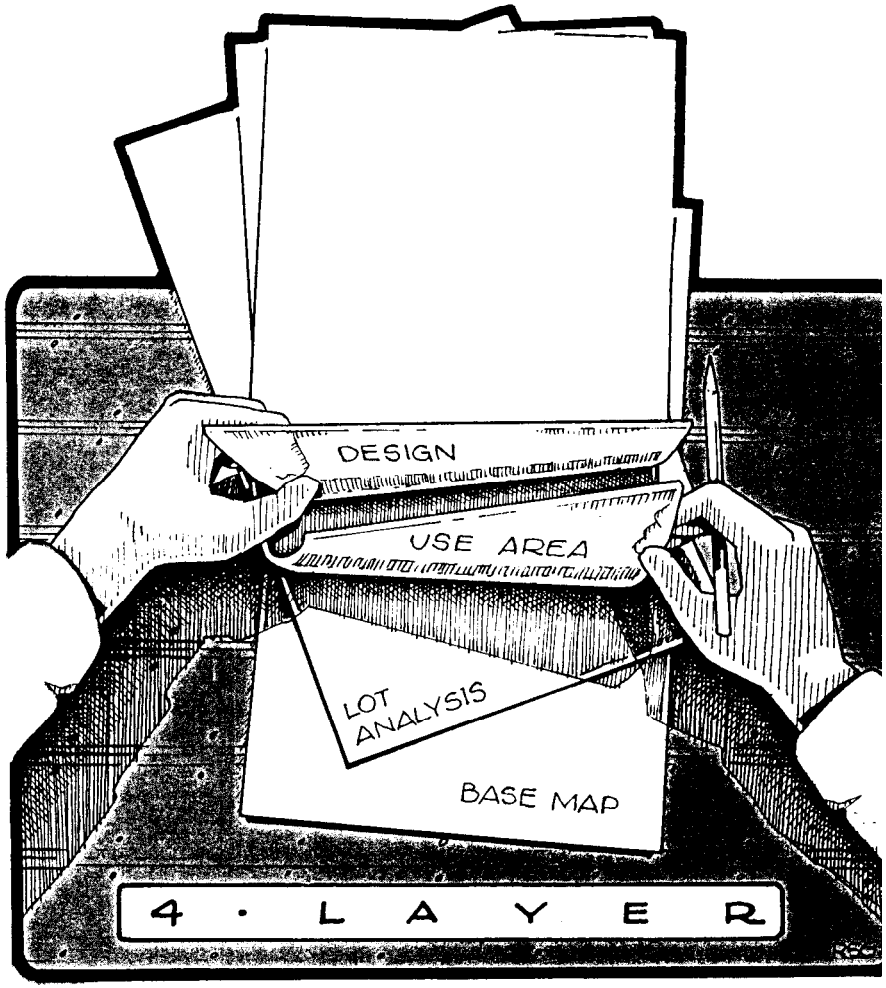
On the drawing board, place the best use area sketch over your base map and lot analysis drawing. On top of this, place a clean sheet of tracing paper.

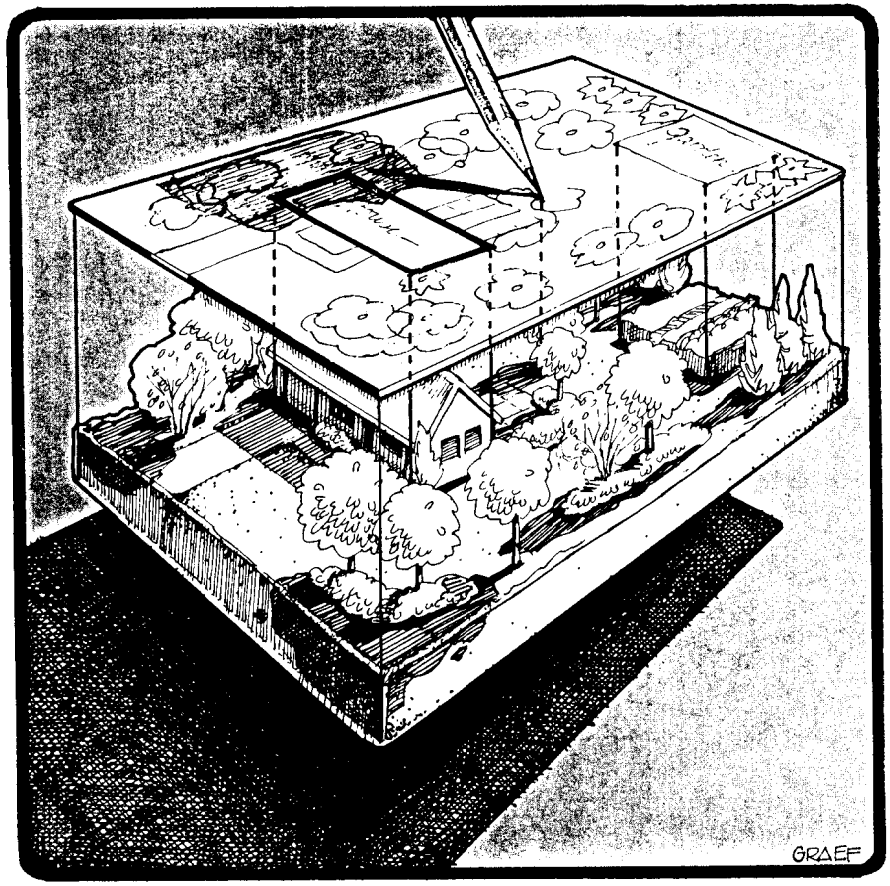
There are three parts to completing your landscape design:

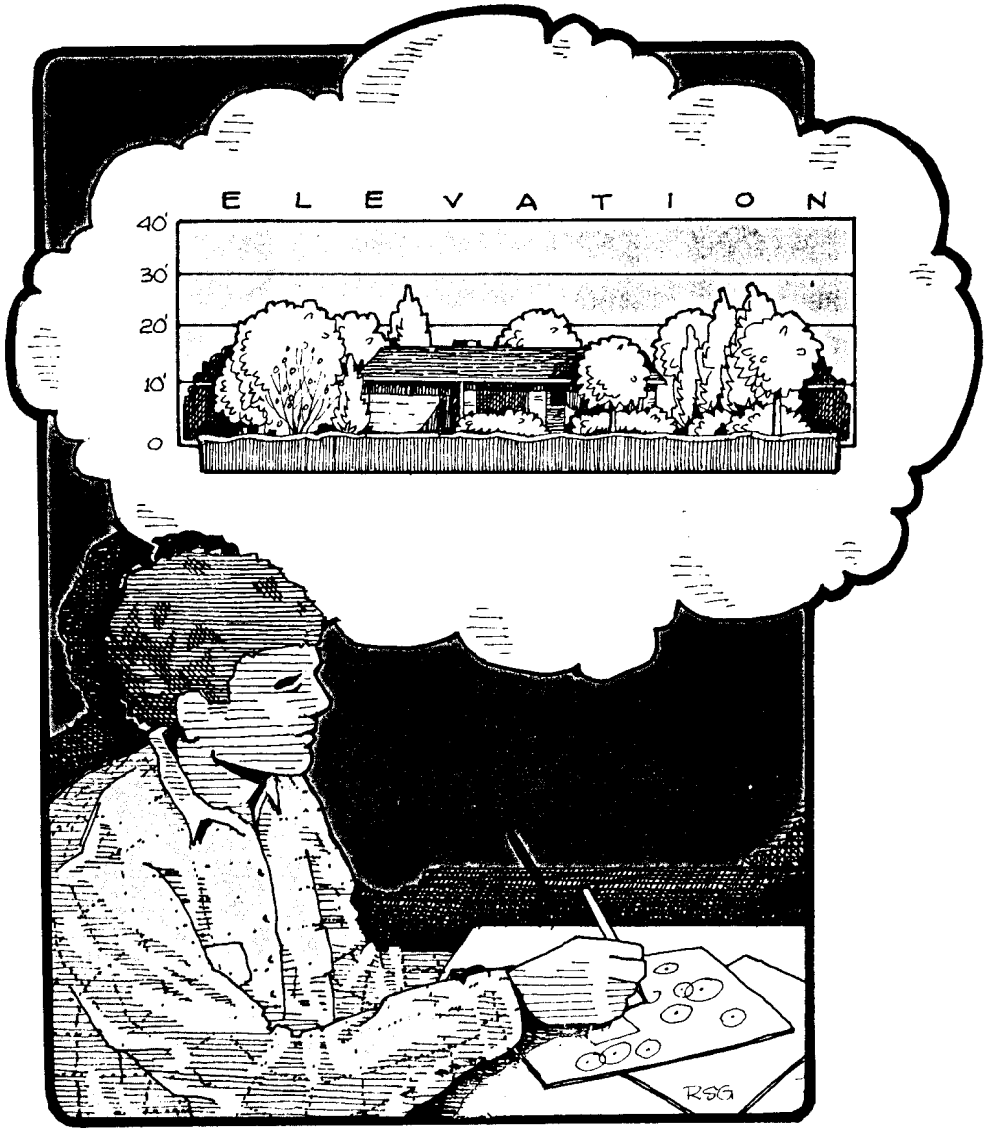
–Draw exact shapes and locations of use areas, planting beds and landscape structures

–Identify specific planting sites

–Select plants and construction materials that meet your design requirements



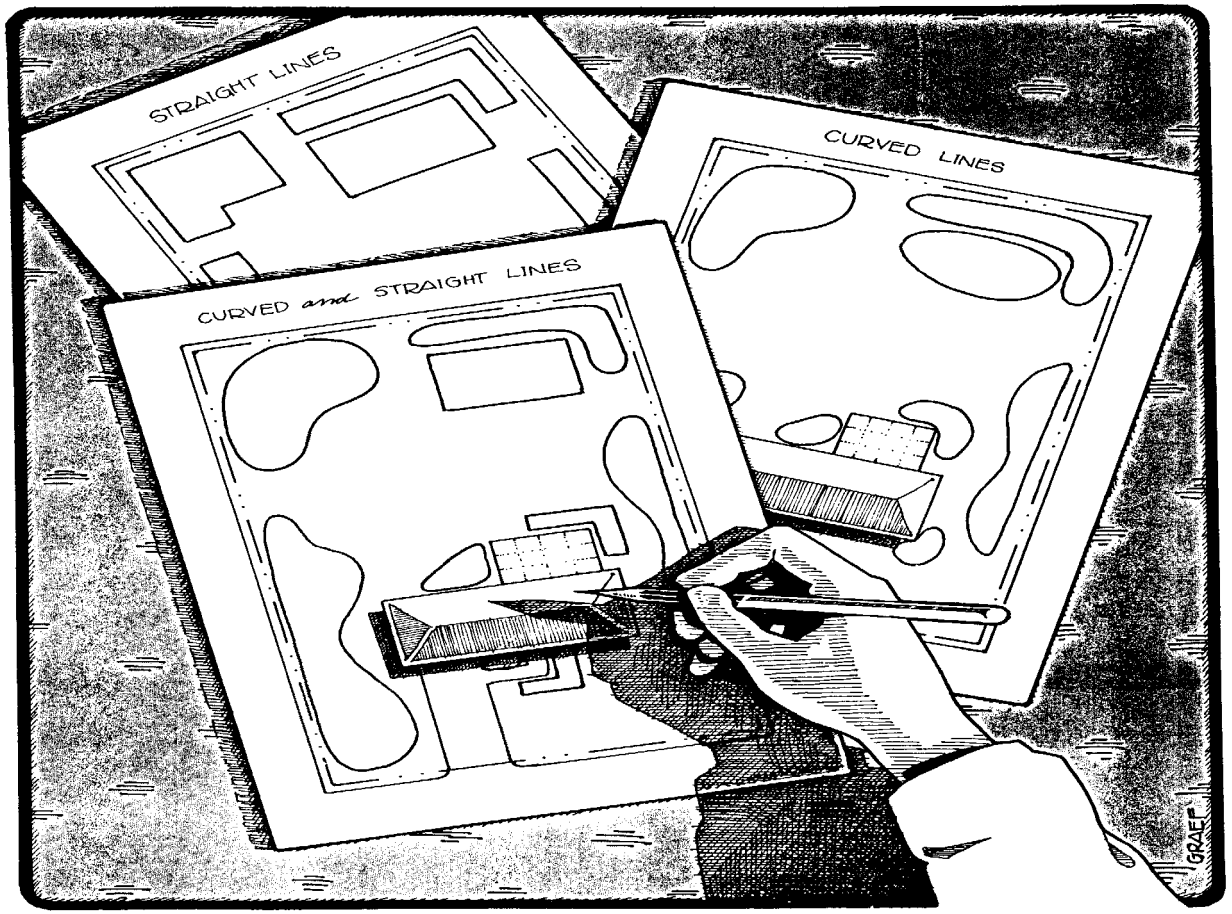

GRAEF


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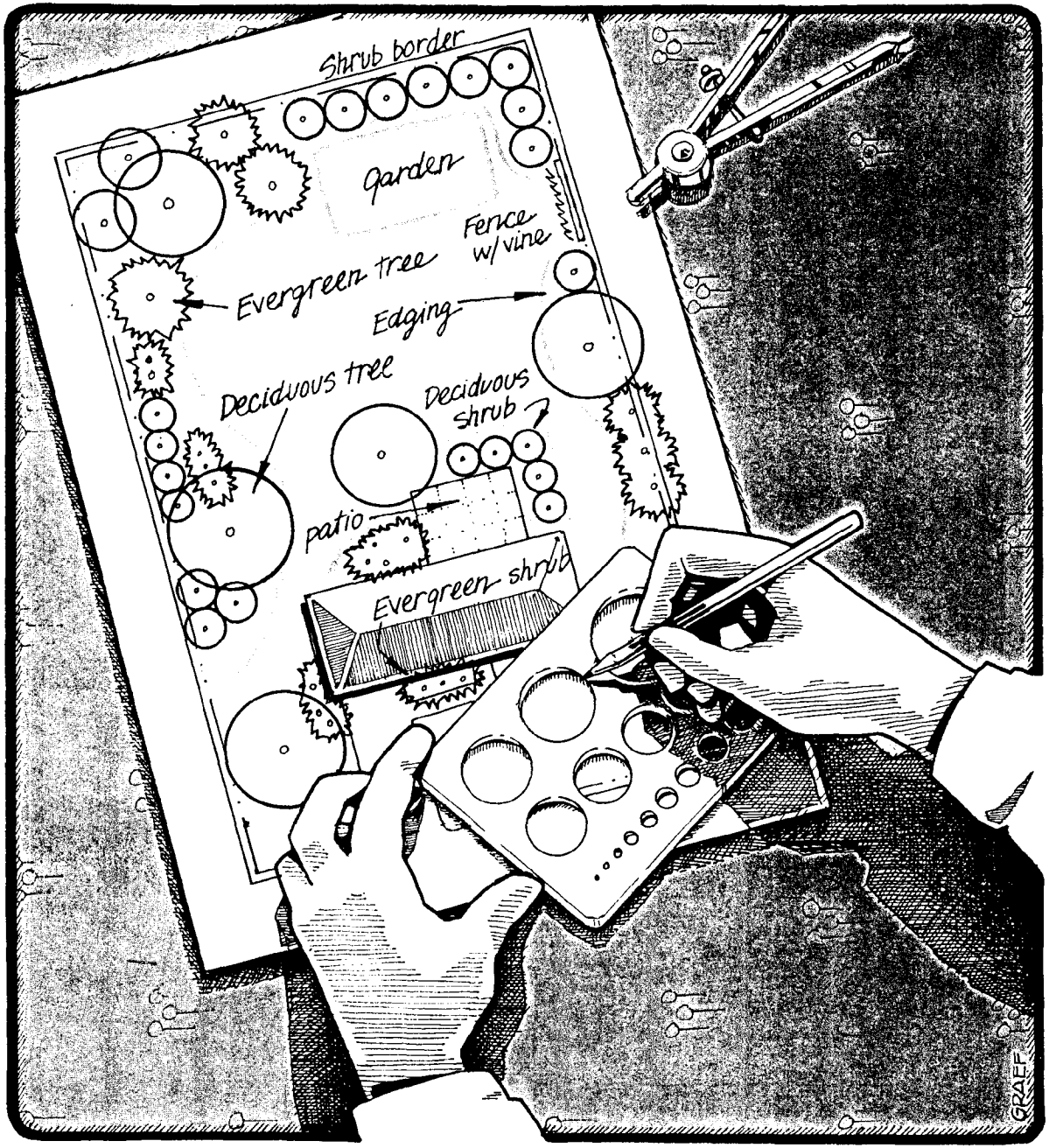
First, draw in planting beds and landscape structures that give shape to your outdoor use areas. As you draw, consider both function – energy conservation, screening poor views, enhancing good ones, etc. – and aesthetics – based on general design principles. You may want to review the relevant sections of this publication as you zero in on the most successful design.

Draw planting beds and landscape structures accurately to scale. You'll need some idea of the types of plants that will go into planting beds – deciduous vs. evergreen trees vs. shrubs, etc. – to make the beds the proper size.

Be prepared to draw several alternative designs. Professional designers usually draw several designs, try to improve them, then select the one that is best all-round.

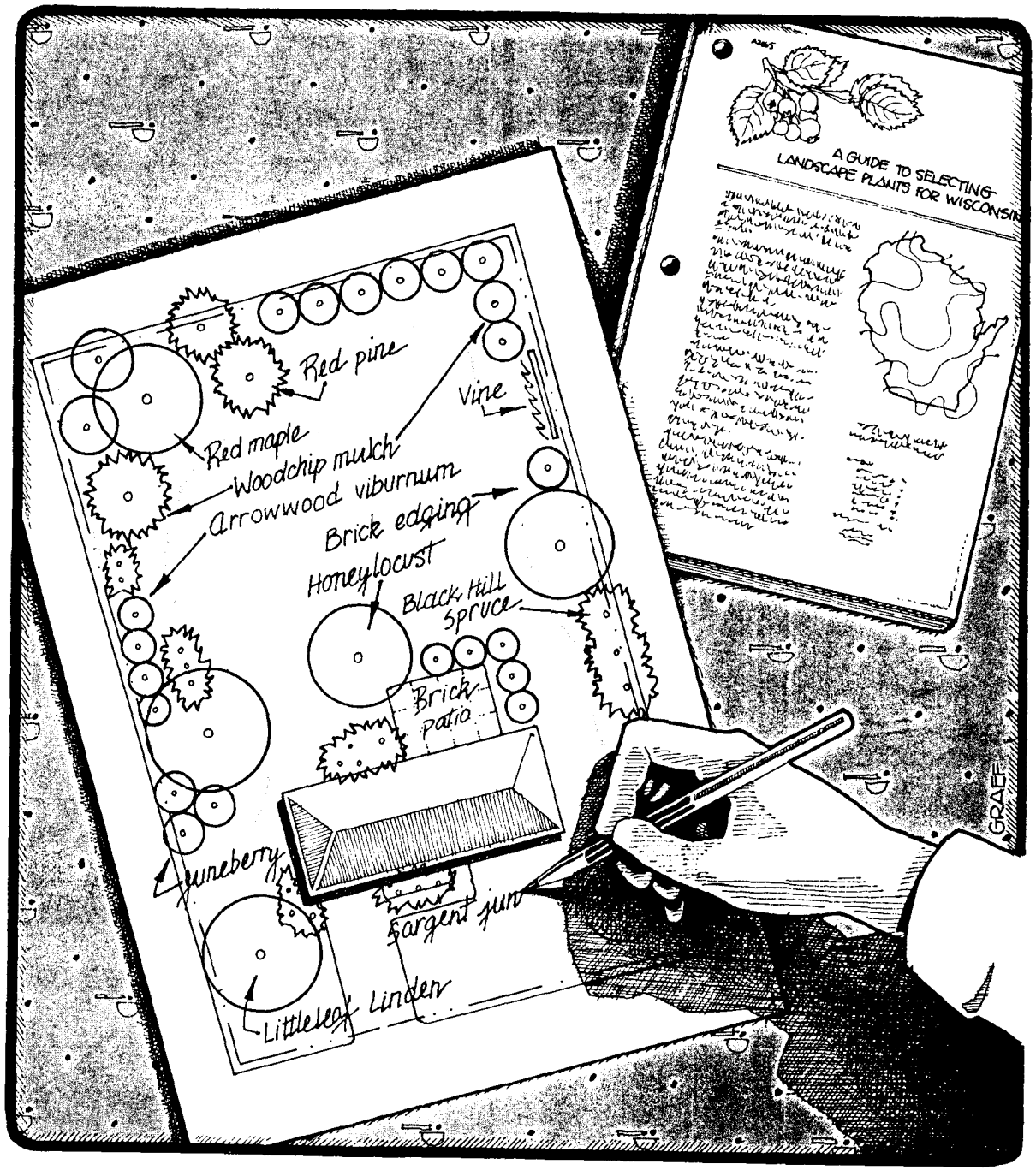


Second, identify exactly where plants should go, using appropriately sized circles on your drawing. Except for very large trees, which are usually drawn about two-thirds their maximum size, draw circles representing approximate mature plant spread. Unless otherwise specified in plant descriptions, spread is usually about two-thirds of listed height. You may want to differentiate deciduous and evergreen plants with different symbols.



Finally, decide what plants and building materials will fulfill your design requirements. The goal is to select plants that will grow well in your planting sites while providing forms, textures and colors that complement your design.

Also choose building materials whose textures and colors complement your design. Structures should blend in with house and plants. If you have a wood-surfaced house, for example, you'll probably want a wooden fence, and its color should be the same as or complement your house color.



For Further Reading

Many publications on subjects related to home landscaping are available through UW-Extension county offices.

Site planning

Catalog number	
G8lNH153	Planning a Play Area in Your Residential Landscape Design

Plant selection

A3382	Container Gardening
A2865	A Guide to Selecting Landscape Plants for Wisconsin
G1609	Landscape Plants That Attract Birds
A3434	Lawn Establishment
G2736	Prairie Primer

Plant care

A1771	Caring for Deciduous Shrubs
A1817	Caring for Your Established Shade Trees
A1730	Evergreens: Planting and Care
NCR356	Fertilizing Garden and Landscape Plants and Lawns
A3073	Identifying Shade Tree Problems
A3435	Lawn Maintenance and Problems
A1990	Lawn Weed Prevention and Control
NCR26	Lawn Weeds and Their Control
A3383	Mulches for Home Gardens and Plantings
A2305	Organic Soil Conditions

Plant care (continued)

Catalog number	
A2079	Recognizing Common Shade Tree Insects
A3067	Selecting, Planting and Caring for Your Shade Tree
A2308	Tree and Shrub Fertilization
A2934	Turf Insect Pest Control Guide
A3134	Woody Ornamental Insect Pest Control Guide

Yard Care and the Environment is a series of publications developed by UW-Extension and the Department of Natural Resources. Titles include:

- *Rethinking Yard Care*
- *Shoreline Landscape Options and Plants*
- *Landscape Practices for Healthier Plants and Improved Water Quality*
- *Lawn and Garden Fertilizers*
- *Lawn and Garden Pesticides*
- *Selecting a Lawn Care Company*
- *Watering*

Other publications

Landscaping for Wildlife, available from the Department of Natural Resources, Box 7, St. Paul, MN 55155-4007. A landowner's guide to developing a beautiful yard that attracts wildlife.

Livable Landscape Design (141IB-211), available from Cornell University Distribution Center, Seven Research Park, Ithaca, NY 14850. Provides a fairly detailed reference on the process and principles of livable residential landscape design.

Basic books on home landscape design are also available at libraries, bookstores and garden centers.

For Assistance

Homeowners who need assistance with developing and carrying out a landscape plan can turn to several sources of professional and technical services:

Landscape architects are professional consultants who plan and design the arrangement of outdoor areas. Of all the sources of landscape services, only landscape architects offer assistance with site selection and planning, preparing alternative plans and selecting a final plan that includes plants and hard-surface materials and working drawings. Some states have regulatory laws governing the practice of landscape architecture. Wisconsin does not require licensing, but only a person who has a degree from an accredited program can properly be called a landscape architect. Most landscape architects specialize in planning and design and do not sell plants or other materials or do landscape construction, in contrast to the following segments of the landscape industry.

Nurserymen grow plants for wholesale or retail sale. Some may offer landscape design assistance, particularly with plant selection and placement. Some may do the planting. Some nurseries operate garden centers.

Landscape contractors specialize in landscape construction They do rough and finish grading, seeding and sodding, concrete work for drives, walks and low retaining walls. They place landscape plants and supply topsoil, asphalt and other construction materials. Some install fences, decks, patios, sprinkler systems and pools. As a rule, landscape contractors do not grow plants, operate garden centers or offer extensive design assistance.

Garden centers sell seeds, fertilizer and plants that they may or may not have grown themselves. Most sell a wide variety of materials, including bedding plants, pottery and patio and lawn furniture. Some may deliver large plants, but few install them. Some garden centers offer limited planting design services.

Most **sod producers** sell sod wholesale, but some retail and install sod for homeowners. As a rule, they do not offer landscape design services.

Landscape industries that offer some landscape design services may employ **landscape horticulturists** – trained specialists in ornamental horticulture who may have some experience in planting design – and **landscape designers** – individuals who may have some experience in residential design, but not necessarily any formal training in landscape design.

Editing, Jerry L. Mosser
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Authors: Dan A. Wilson and Thomas J. Wilson are University of Wisconsin–Extension community resource agents in Washington and Marathon County, respectively. Both are landscape architects. Wayne G. Tlusty is a professor of landscape architecture at the College of Agricultural and Life Sciences, University of Wisconsin–Madison and the University of Wisconsin–Extension, Cooperative Extension.

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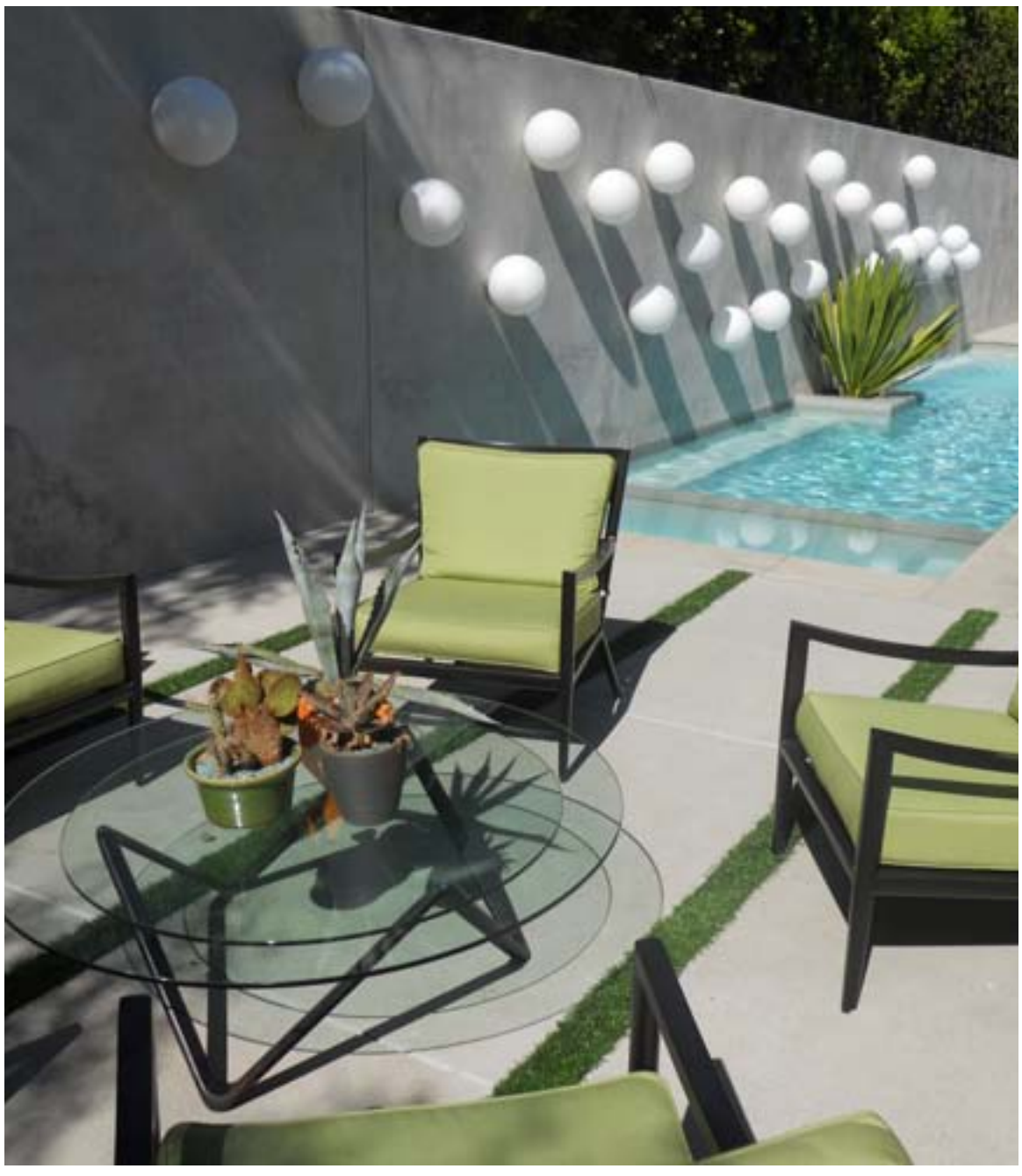
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Planning and Designing Your Home Landscape (G1923)

RP-02/2004

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A Complete Collection of LANDSCAPE STYLES

Your guide to materials, décor, plant palettes, color palettes, and fabrics for the most popular garden design themes









A Complete Collection of

LANDSCAPE STYLES







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A Collection of

MEDITERRANEAN LANDSCAPE STYLES

Spanish. Tuscan. French. Southwest.



MEDITERRANEAN: SPANISH LANDSCAPE DESIGN

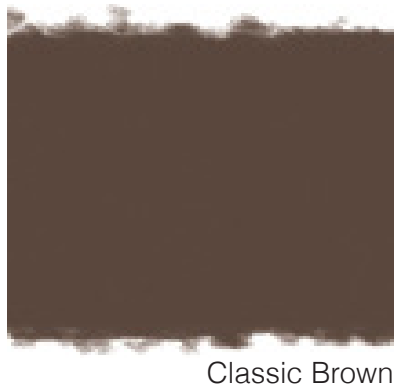




Brilliant Blue



Baked Terra Cotta



Classic Brown



Oxford White

The only thing missing on the sunset-colored pavers of a Spanish-styled abode is the clip-clop of a famous black horse and its enduringly handsome masked rider. Hail to the cavaliers that harbor amongst the bougainvillea and tiered fountains of the hacienda. For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Tiered Spanish Fountains



Urns



Moorish Lanterns



Carved Cantera Forms

MATERIALS



Plaster



Slump Block



Saltillo Tiles



Cantera Stone

PLANT PALETTE



Mediterranean Fan Palm



Pomegranate



Citrus



Agave



Bougainvillea



Cactus

FABRICS



Kamal Chestnut



Pacific Blue

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MEDITERRANEAN: TUSCAN LANDSCAPE DESIGN




Olive Moss


Tangerine Mist


Sunset Boulevard


Pink Peach

Nothing could be sweeter than a wall fountain that trickled wine, splashing droplets of fermented grapes into glass goblets. Imagine yourself under the Tuscan sun, among the vines and columns of another era, enjoying the sweet rewards of your villa.
For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR


Hedges


Ionic Columns


Wall Fountains


Armillary

MATERIALS


Plaster


Travertine


Pebble Mosaic


Ironwork Hinges

PLANT P ALETTE


Fig


Italian Cypress

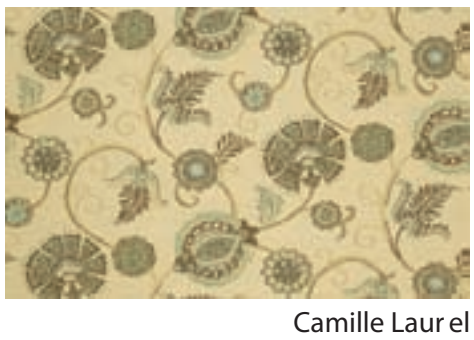

Rosemary

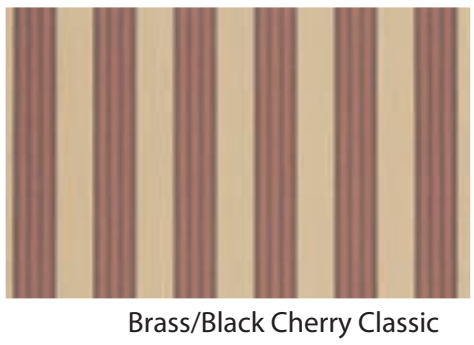

Acanthus


Boxwood


Olive

FABRICS


Camille Laur el

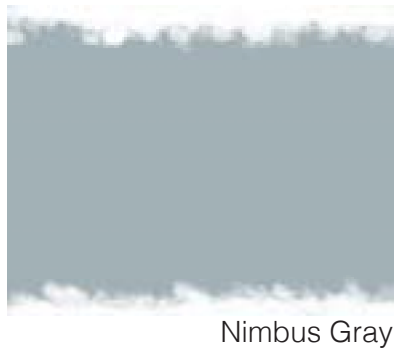

Brass/Black Cherry Classic

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MEDITERRANEAN: FRENCH LANDSCAPE DESIGN

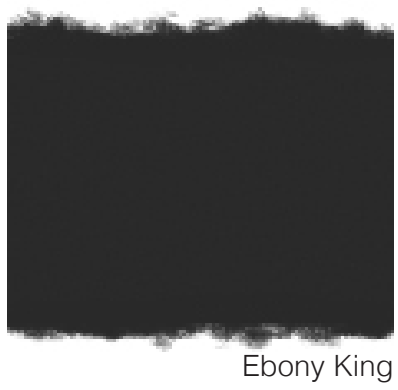




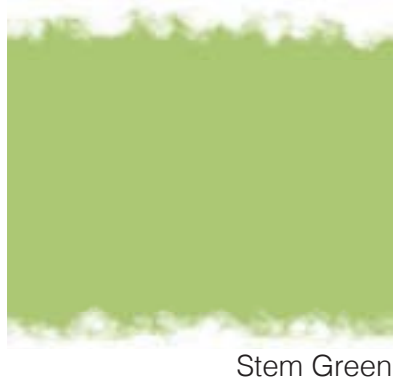
Nimbus Gray



French Lilac



Ebony King



Stem Green

Hemingway once said—"If you are lucky enough to have lived in Paris as a young man, then wherever you go for the rest of your life, it stays with you, for Paris is a moveable feast." Much like the gardens of Versailles, French-inspired gardens are a feast for the eyes with topiaries, lavender, and cypress as the table settings.

that marry the interior with the exterior. You get the picture.

For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Concrete Balustrade



Topiary Shrubs



Cast Iron Seating



Concrete Fountain

MATERIALS



Pea Gravel



Porcelain Tiles



Marble



Decomposed Granite

PLANT PALETTE



Allium



Boxwood



French Lavender



Pear



Thrift

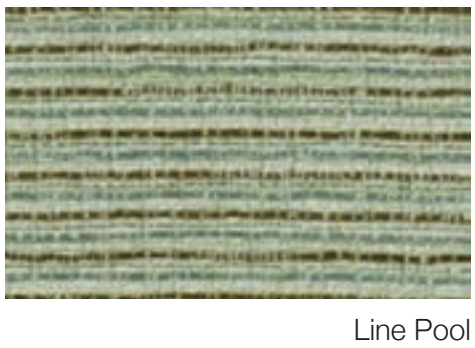


Rockrose

FABRICS



Fiery Blast Twine



Line Pool

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MEDITERRANEAN: SOUTHWEST LANDSCAPE DESIGN





Minstrel Heart



Mother Earth



Navajo Red



Warm Earth

There are certain historical feuds we'll never forget, such as the Hatfields and McCoys, or Al Capone and Bugs Moran. The Southwest style is no different. With beehive fireplaces, animal skin rugs, branding irons and spurs, it's hard to tell if you like the cowboys or the Indians. For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Fountains



Native American Fabrics



Olla Pottery



Native American Art

MATERIALS



Red Clay Pavers



Arizona Flagstone



Stacked Stone



Plaster

PLANT PALETTE



Yucca



Agave



Sage



Palo verde



Desert Spoon



Succulents

FABRICS

Tan

Westfield Salsa

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A Collection of

TRADITIONAL LANDSCAPE STYLES

Colonial. Saltbox. Townhouse. English. Craftsman.



TRADITIONAL: COLONIAL LANDSCAPE DESIGN





Slate Blue

Chalk White



Hunter Green



Standish White

From the balcony of the Colonial estate, don't be surprised if you hear the call of Paul Revere in the night. It's also not uncommon for white-haired, pony-tailed men to arrive at your door by horse and buggy. The stately columns and stone walls may revolutionize your way of thinking. For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Sun Dial



Rustic Picket Fence



Arbors



Antique Mill Stone Fountain

MATERIALS



Stone walls



Stone Pavers



Slate

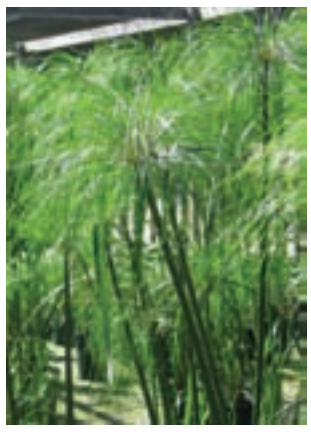


Pickets

PLANT PALETTE



Hydrangea



Papyrus



Echinacea



Phlox



Lilac



Roses

FABRICS



Mahogany/Brass Vintage



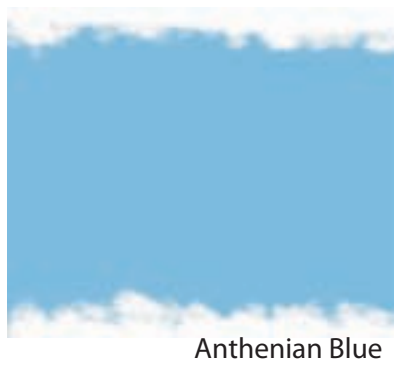
Dupione Henna

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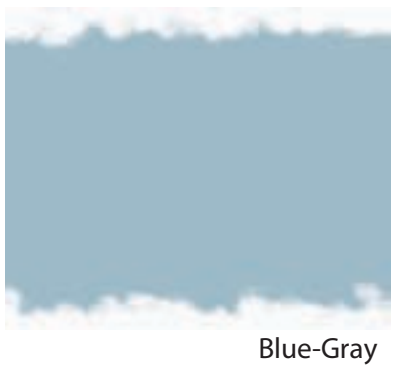
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TRADITIONAL: SALTBOX LANDSCAPE DESIGN





Anthenian Blue



Blue-Gray



Harbor Gray

Chalk White

Remember your childhood, and the fluttering white curtains in the bedroom window on midsummer's evening. The chirping bird atop the windowbox was not only there for your enjoyment, but was welcoming Mary Poppins in on the breeze. The saltbox home is characteristic of charming memories and an occasionally prude but mesmerizing nanny.
For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Windowbox



Traditional Bird Bath



Bird Houses



Pergola

MATERIALS



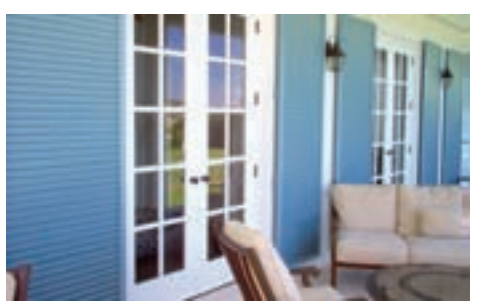
Brick



Clapboard



Pickets



Shutters

PLANT PALETTE



Flax Lily



Rosa Rugosa



Ornamental Grasses



Red Twig Dogwood



Virginia Creeper



Flowering Crabapple

FABRICS



Navy/Taupe Fancy



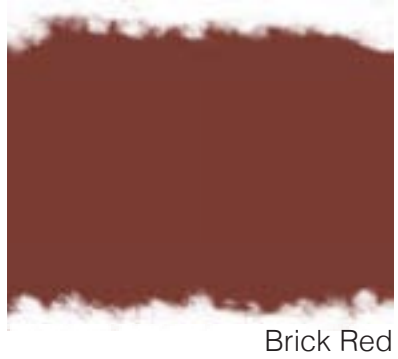
Rib Sky Blue

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TRADITIONAL: TOWNHOUSE LANDSCAPE DESIGN





Brick Red



Mocha Brown



Caramel Latte

Standish White

The "house in town" was the home of aristocrats during the social season of the year when they relocated from their country houses. The often wealthy Londoners enjoyed the terraced vistas of the townhouse. Now the vistas are yours to enjoy...at least while parliament is still in session. For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Wrought Iron Fence



Cast Iron Bench



Wood Planting Box



Cast Iron Urn

MATERIALS



Brick



Iron



Granite



Brownstone

PLANT PALETTE



Fountain Grass



Hebe



Ferns



Hosta



Dogwood



Yew

FABRICS



Eastland Redwood



Mahogany

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TRADITIONAL: ENGLISH LANDSCAPE DESIGN



Gentle Gray

Minstrel Heart

Chatsworth Cream

Olive Moss

Heavy chimneys, half-timbering and dark wood paneling make every English style home seem like its gardens are automatically labeled "secret". There's always something intriguing, albeit epic to discover, such as wardrobes that open to wintry fantasy worlds. For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Wattle Edging & Panels



Bee Skep



English Garden Bench



English Pots

MATERIALS



Brick



Thatch

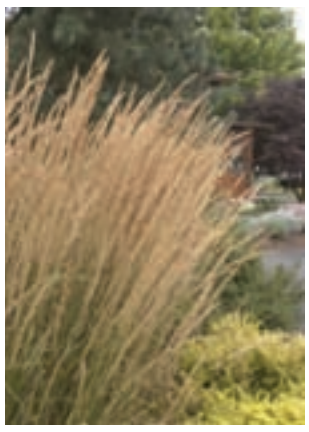


Limestone



Cobblestone

PLANT PALETTE



Reed Feather Grass



Coneflower



Daylily



Delphinium



English Roses



Sweet Pea

FABRICS



Cabaret Blue Haze



Grey/Beige Chip Fancy

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TRADITIONAL: CRAFTSMAN LANDSCAPE DESIGN





Baked Terra Cotta



Bright Gold



Fresh Olive

Cool Mint

The Woodworkers Association concurs, it takes a craftsman to build a craftsman. While you're hand-hammering your copper sink, remember to stop and smell the Magnolia tree and reflect on a time when the hand-made was preferred over the mass-produced. For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Adirondack



Ceramic Pots



Hammered Copper Fire Pit



Wood Gate

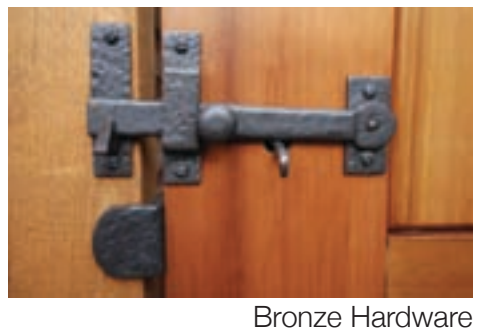
MATERIALS



Wood Siding



Copper Gutters



Bronze Hardware



Cobblestone

PLANT PALETTE



Daylily



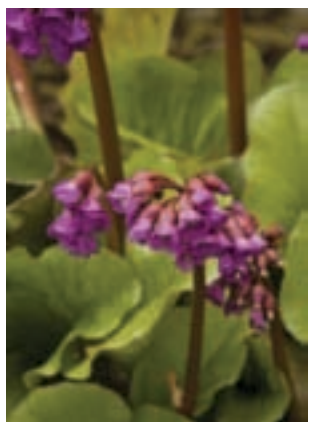
Acanthus



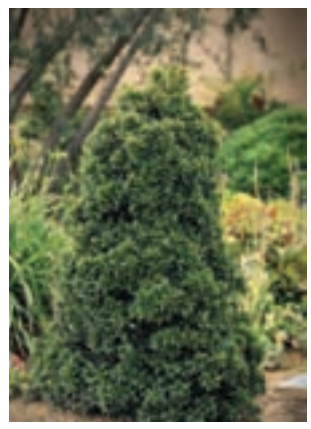
Nandina



Passionflower



Bergenia

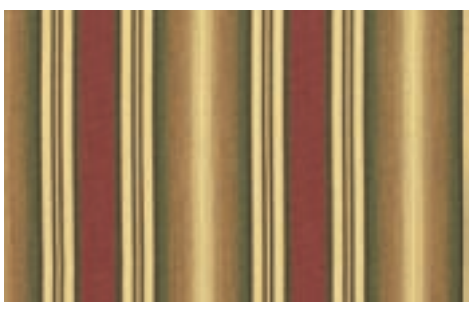


Eugenia

FABRICS



Hendrix Clay



Weston Ginger

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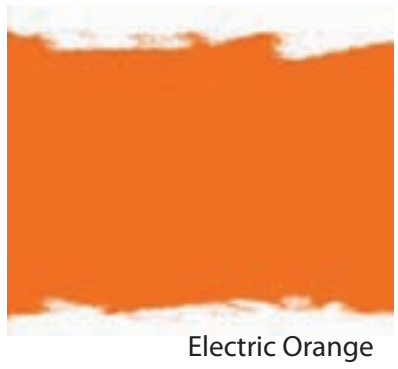
TROPICAL LANDSCAPE STYLES

South Pacific. Asian. Coastal.



TROPICAL: SOUTH PACIFIC LANDSCAPE DESIGN





Electric Orange



Dearborn Tan

Sweet Honeydew Melon



Cool Lava

It's 1958...love blooms between a young nurse and a secretive Frenchman. The island is iconic. The combination of bamboo, teak, thatch, tiki and wicker are an instant revival. While you're enjoying your umbrella drink, try not to break out into song.

For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Tiki



Thatch Umbrella



Terracotta Urns

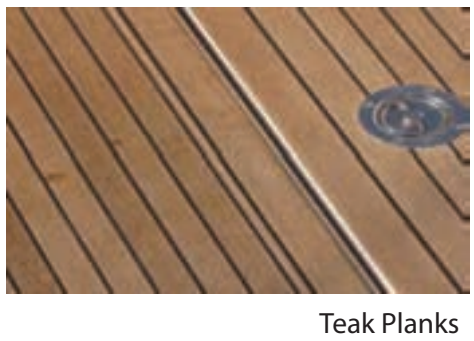


Asian Figures

MATERIALS



Thatch



Teak Planks



Bamboo



Teak Furniture

PLANT PALETTE



Bougainvillea



Colocasia



Orchid



Banana



Dracaena



Canna

FABRICS



Dolce Mango



Canvas Sunflower Yellow

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TROPICAL: ASIAN LANDSCAPE DESIGN





Baby Fern



Champion Cobalt



Sundried Tomato



Stone Hearth

Harmonious. Inner peace. Silence. Understanding. Relationship. Environment. Spirit. Breathe. Think. If the Oriental style is known to conjure up good health and good vibes...why doesn't everyone do this?

For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Pagoda Light



Bamboo Fencing



Bonsai



Bamboo Fountain

MATERIALS



Pea Gravel



Decomposed Granite



Sand



Natural Stone

PLANT PALETTE



Japanese Maple



Weeping Atlas Cedar



Azalea



Moss



Star Magnolia



Flowering Cherry Tree

FABRICS



Kamal Chestnut



Dupione Palm

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TROPICAL: COASTAL LANDSCAPE DESIGN

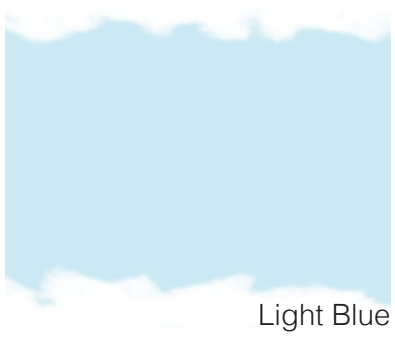


Painted Sands

At Sea



Steel Wool



Light Blue

If you live by the beach, you're one of the few and the proud to display teak and rattan. If you just like the look of sea shells and coral in your Nebraska home, then well, that's just awkward. Keep the marine artifacts and the hairdos that do well in the marine layer by the marina. For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Hammock



Seagrass Furniture



Marine Artifacts



Shutters

MATERIALS



Teak



Clapboard



Exposed Aggregate



Steel

PLANT PALETTE



Mexican Feather Grass



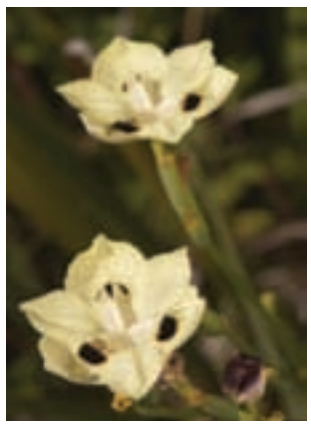
New Zealand Flax



Natal Plum



Verbena



Fortnight Lily



Palms

FABRICS



Caroline Sunbreeze



Dupione Seafoam

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A Collection of

COUNTRY LANDSCAPE STYLES

Farmhouse. Victorian. Ranch. Rustic.



COUNTRY: FARMHOUSE LANDSCAPE DESIGN





Rust



Blanched Almond

Soft Sky

White Diamond

Warm and lovely days, lemonade, and picket fences are reminiscent of the country farmhouse. In the evenings, while you sip spirits on the lightly lit porch, you might hear the soft neigh of a horse. If you listen carefully, you just might hear John Walton call out, "Good night, John-Boy." For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Bent Willow Furniture



Wicker



Wishing Well



Birdhouse

MATERIALS



White Picket Fence



Post & Rail White Fence



Wood Tiles



Painted Wood

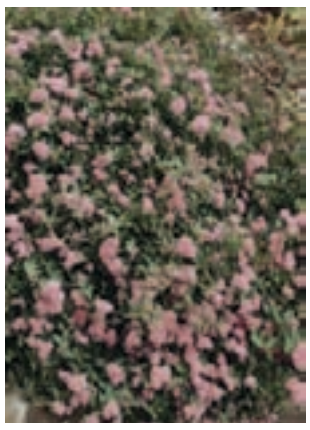
PLANT PALETTE



Hydrangea



Butterfly Bush



Spiraea



Shrub Roses



Wisteria



Azalea

FABRICS



Brannon Redwood



Rib Sky Blue

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COUNTRY: VICTORIAN LANDSCAPE DESIGN




Peony


Blue Springs


Gardenia


Richmond Green

Elaborate ornamentation with a touch of whimsy describes the detailed bay windows, turrets, dormers, lattice, gazebos, and fancy wicker of the Victorian house. All are sure signs of a bygone era when horses and petticoats were more common than cars and telephones. For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR


Gazebo


Cast Iron Fountain


Wicker Furniture


Cast Iron Bench

MATERIALS

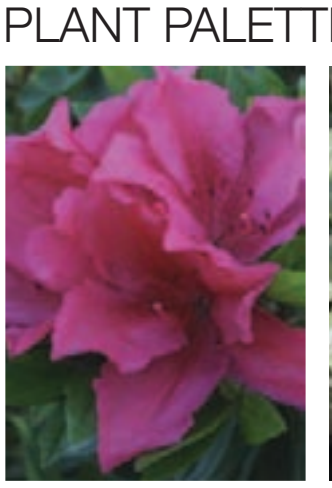

White Aged Wood


Carved Wood Columns


Lattice


Cast Iron

PLANT PALETTE


Azalea


Pittosporum


Wisteria


Hydrangea


Forsythia


Spiraea

FABRICS


Leigh Lemon


Marcello Seagrass

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COUNTRY: RANCH LANDSCAPE DESIGN





Merlot Red



Cloud Nine



Guesthouse



Plymouth Brown

Nearly every sprawling, ranch-style home is one story. So who said those cowboys weren't thinkin' when they designed their homes on one level. It's hard to walk up stairs after a long day fixin' fences. Plus, why waste time when there's a perfectly good wagon wheel bench to sit on and a rusting tractor to look at.

For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Wagon Wheel



Rustic Truck



Tree Swing



Pergola

MATERIALS



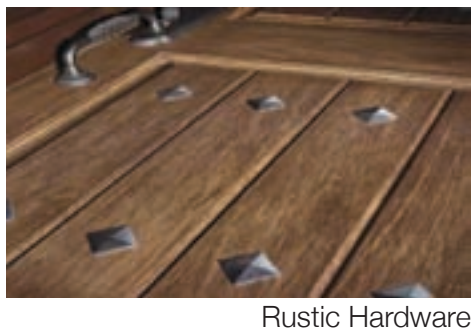
Stone Paving



Split Rail Fence



Flagstone Veneer



Rustic Hardware

PLANT PALETTE



Salvia



Pine



Honeysuckle



Redwood



Aspen



Oak

FABRICS



Harwood Crimson



Simone Flame

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COUNTRY: RUSTIC LANDSCAPE DESIGN





Ferret Brown



Alligator Alley



Rustic Brick



Rusty Nail

If you have a rustic-style house, forego the fake deer in the front yard. You probably live in the boonies anyways where deer and sasquatch sightings are a regular occurrence. Or maybe you just like the lodgepole, flagstone, bent willow furniture look when you're sipping coffee by your lake. For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Fire Pit



Bent Willow Furniture



Rustic Shade Arbor



Twig Fence

MATERIALS



Redwood



Lodgepole Pine



Cedar



Local Flagstone

PLANT PALETTE



Deer Grass



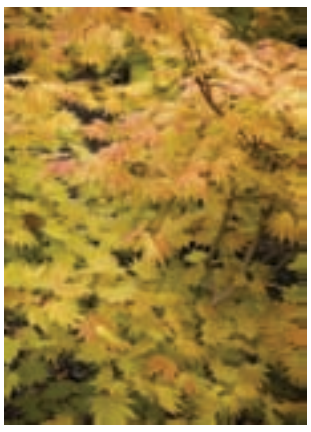
Pine



Bleeding Heart



Native Hydrangea



Maple



Fern

FABRICS



Dash Redwood



Resonance Mahogany

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A Collection of

MODERN LANDSCAPE STYLES

Art Deco. Modern. Mid-Century.



MODERN: ART DECO LANDSCAPE DESIGN





Festive Orange



Snow Cone Green



Jet Black



Metallic Silver

Hollywood isn't the only place associated with elegance and glamour. Art deco homes are a lot like celebs...influenced by a lot of people and photographed often. Luckily when an art deco home needs to be remodeled, it might get a makeover but it doesn't have to go to rehab. For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

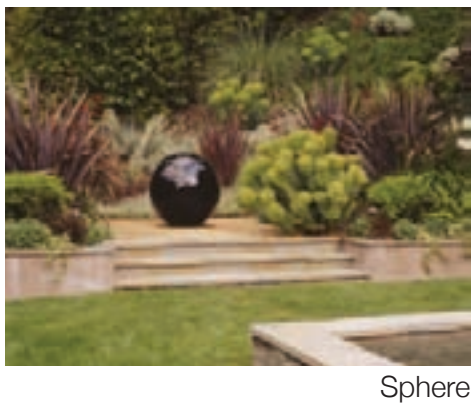
DECOR



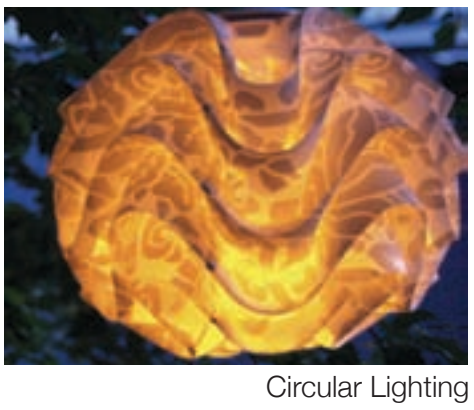
Slate Fountain



Gabion Forms



Sphere



Circular Lighting

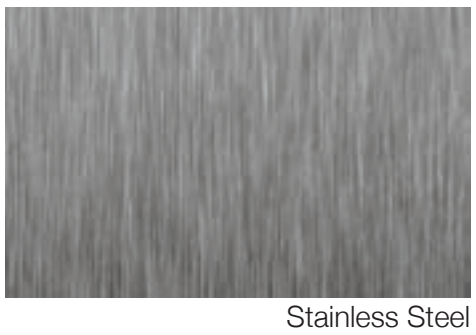
MATERIALS



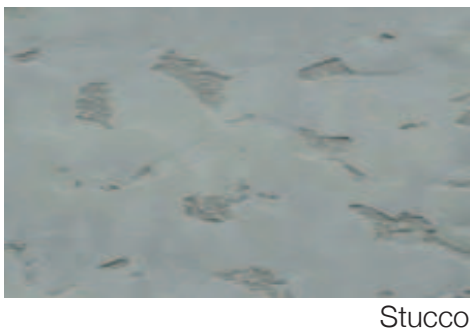
Poured Concrete



Glass Blocks

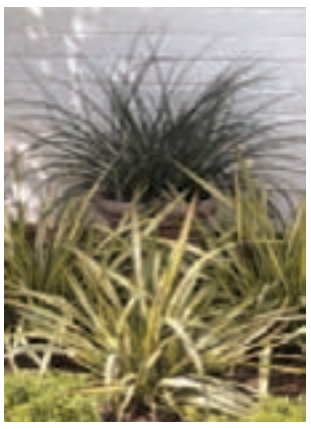


Stainless Steel



Stucco

PLANT PALETTE



New Zealand Flax



Orchid



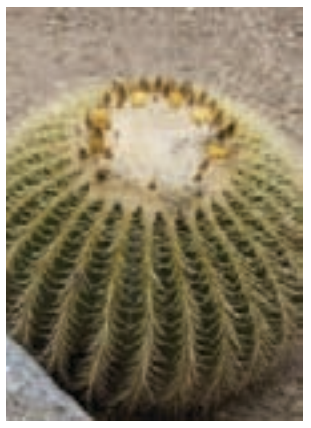
Bird of Paradise



Citrus



Canna



Cactus

FABRICS



Aruba



Canvas Coal

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MODERN: MODERN LANDSCAPE DESIGN





Blue Macaw



Electric Orange



Metro Gray



Neon Lime

What does a square, a baby's butt, and a windsurfing board have in common? They're the makeup for a modern design. Okay, maybe it would be better described as geometrical, smooth, and streamlined, characterized by expansive, unadorned windows that marry the interior with the exterior. You get the picture.

For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Art Furniture



Modern Sculpture

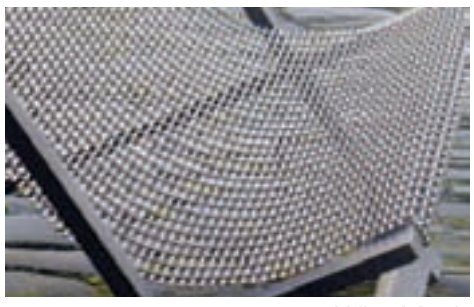


Fire Feature



Water Feature

MATERIALS



Wire Mesh



Cable Rail

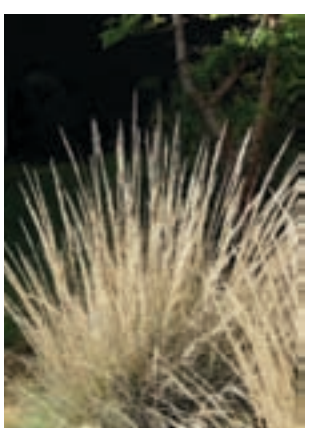


Metal Mesh Panels



Wood Siding

PLANT PALETTE



Deer Grass



Yucca



Dracaena Palm



Succulents



Cactus



Sago Palm

FABRICS



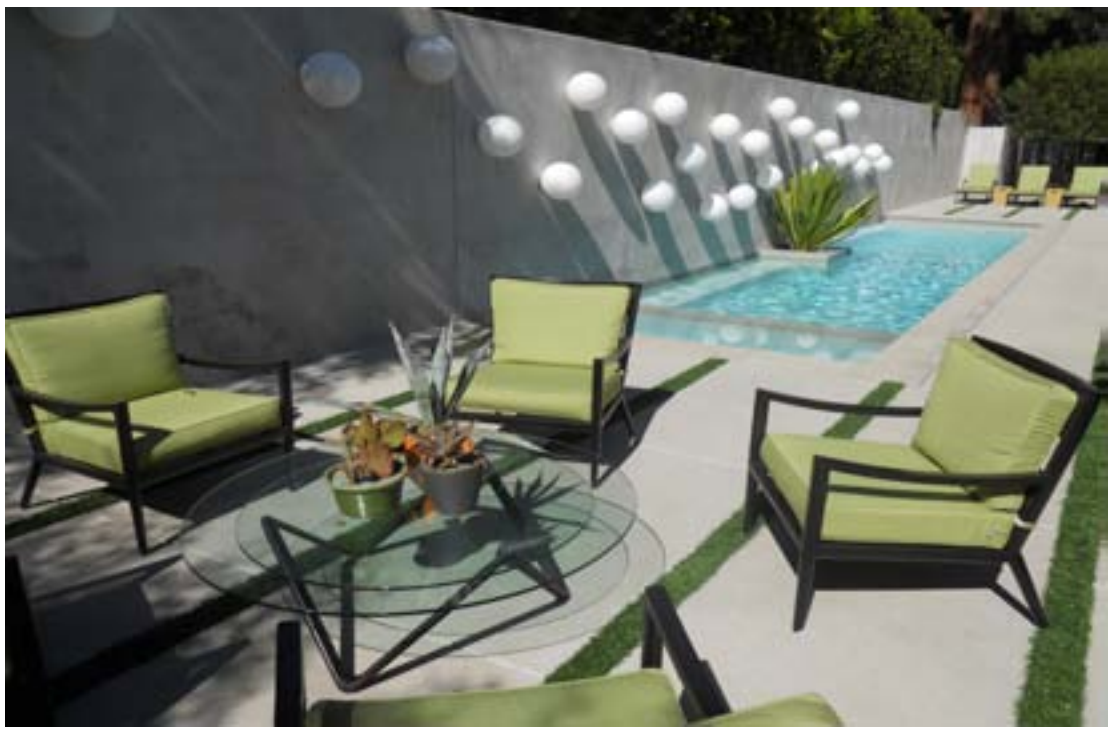
Orange

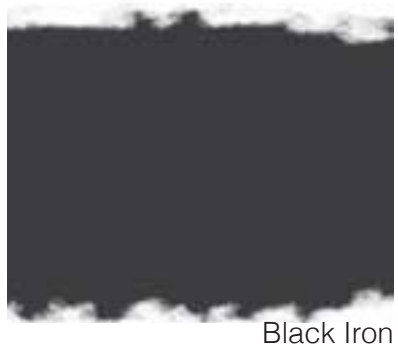


Melbourne Parrot

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MODERN: MID-CENTURY MODERN LANDSCAPE DESIGN

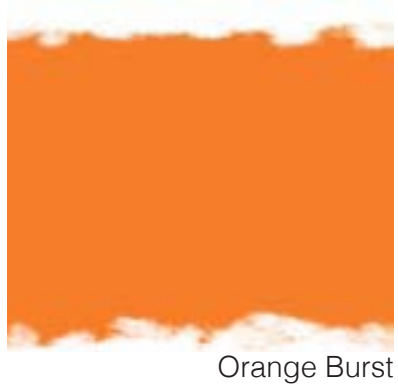




Black Iron



Mother Earth



Orange Burst



Vine Green

A mid-century modern home is George Jetson with a dash of Frank Lloyd Wright—a little bit retro mixed with space-age funky. Nonetheless this mid-20th century marvel is recognized by scholars and museums as a significant design movement. The only thing missing is a dog named "Astro." For more garden design ideas, visit: www.landscapingnetwork.com/garden-styles

DECOR



Portable Lamp



Vintage Furniture



Wood Bench



Contemporary Shade Structure

MATERIALS



Natural Wood Glulam Beam



Poured Concrete



Stucco



Stainless Steel

PLANT PALETTE



Yucca



Agave



Cordyline



Horsetail



Gazania

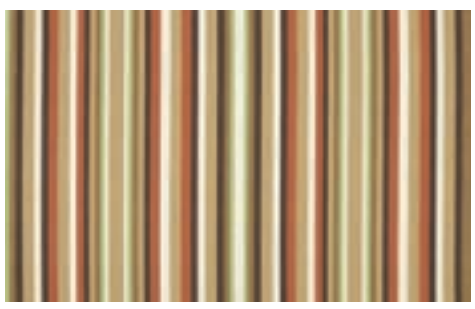


Black Pine

FABRICS



Spectrum Kiwi



Scavo Autumn

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Using COLOR to Set the Mood in the Landscape

LandscapingNetwork.com
By: Renee' Brown

PINK
Innocent, Soothing
Coordinating colors:



pink ladies

black iron

These pink cushions bring a playful, feel-good vibe under a somewhat overwhelming patio cover. The bright fabric and black furniture draw the eye into the soothing seating area.

RED
Excitement, Romantic
Coordinating colors:

red

grey timber wolf



The color of this wall makes a bold statement creating excitement and intrigue. At the same time, the privacy and seclusion it affords are perfect for a secluded, romantic space.

GRAY
Practical, Reliable
Coordinating colors:



smoke

burnt carmel

The practicality of simple gray tones need not stay muted. When accented by a warm color such as the carmel walls of this house, gray offers the reliable basis for nearly any design scheme.

ORANGE
Energetic, Enthusiastic
Coordinating colors:

racing orange

azores



The entry way to this residence is bright and inviting. It's welcoming feel gives visitors a sudden sense of energy and excitement for what lies ahead.

BLACK
Authority, Sophisticated
Coordinating colors:



black iron

satchel

The black iron speaks volumes about what this patio is all about. It conjures up a powerful impression in a sophisticated yet fun entertaining area.

YELLOW
Happy, Optimistic
Coordinating colors:

amarillo

ravishing red



A bright and positive entry such as this can't help but brighten your day. The long, narrow corridor to the courtyard gets visitors excited and optimistic that they won't be let down once they get to the end.

BROWN
Elegant, Stability
Coordinating colors:



saddle brown

myan gold

The solid, earthy appeal of brown in a landscape helps bring connection to the garden. The size and warmth in the varying tones of brown, gold, and blue in this fountain add a simple elegance to the soothing sound of water.

GREEN
Refreshing, Relaxing
Coordinating colors:

woodland green

adagio



Natural and rejuvenating, the color green freshens a space. It adds just the right amount of color for this relaxing, mid-century retreat.

PURPLE
Dramatic, Motivating
Coordinating colors:



mystical grape

veranda view

The dramatic impact of an entry filled with purple salvia adds a lot of curb appeal. Contrasting with the bright green tones of the landscape, the effect is inspiring.

BLUE
Calming, Serene
Coordinating colors:

franklin lakes

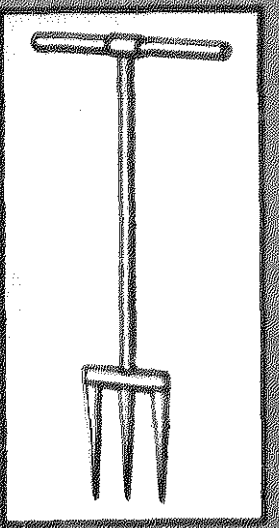
antique rose

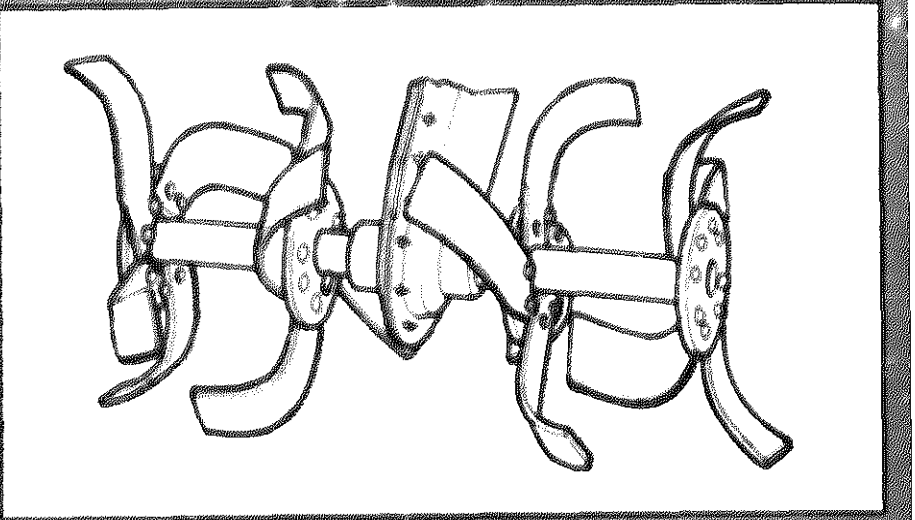


The calm, at-peace feeling of a stroll through this garden is achieved by planting design. The blue agave and grasses create a serene environment suitable for reflection and relaxation.

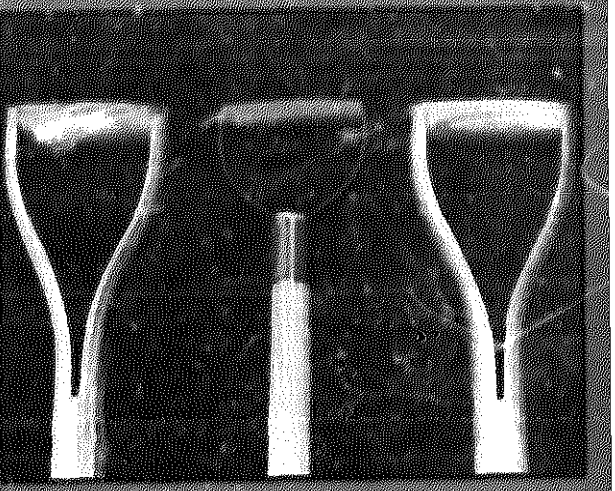
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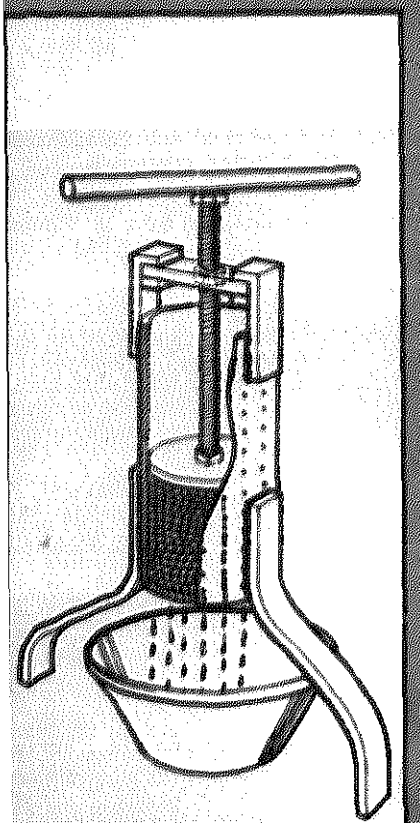












TOOLS

for Homesteaders, Gardeners, and Small-Scale Farmers

A catalog of hard-to-find implements and equipment

by the editors of Organic Gardening®, New Farm®, and Intermediate Technology Publications

edited by Diana S. Branch

$12.95
In Canada $14.95

TOOLS

for Homesteaders, Gardeners, and Small-Scale Farmers

Whether you are a gardener, homesteader, or small-scale farmer, finding the right tools can be a critical problem. Tools can mean the difference between staying on or leaving the land, between a sense of drudgery and a sense of fulfillment, between a successful crop and a meager harvest, between profit and loss. This catalog was compiled to help you find and use the tools you need to produce food. It attempts to fill the gap brought about by what the late E. F. Schumacher of the Intermediate Technology Group in London termed "the Law of the Disappearing Middle." This law states that as technology steadily moves to higher planes, we are left with primitive, overly simplistic tools on the one hand, and a very complex, sophisticated technology on the other.

The magic of any book is in the possibilities it raises in the imaginations of its readers. There are forgotten tools that could be made again — only better — and future tools not yet dreamed of. The ideas for them could spring from the obsolete tools of the past. Along with the new tools in this book, you'll find pictures of farm tools from old manuals. Studying the anatomy of a 1930 tractor which is especially suitable to the needs of today's farmstead, a handy person might just be persuaded to build another one. Or more.

Some tools now marketed for special purposes have uses for growers that the equipment maker didn't foresee. For example, a supplier of orchard and fruit-farming equipment manufactures a mulch spreader for the commercial strawberry grower. But the mulcher could be used to lay down straw or spoiled hay between raspberry rows, or vegetables, or wherever you need it.

Common lawn and garden tools have uncommon homestead uses, too. A grinder-shredder will chop silage for cattle feed out of corn, pumpkins, mangels, or other plants. It will even grind a crude corn-and-cob meal for cows. A big 10-tined silage hand fork makes an excellent tool for handling mulching materials like shredded bark. The equally large hand forks we used to call barley forks, with tines closer together than those of a silage fork, are good for shoveling sawdust mulch.

This book brings together all these tools and the ways to use them. People say that tools aren't available today for homesteading and small-scale farming. But somewhere in the world or at some point in recent history the technology has existed for these tools. They are being made today, and this book tells you where to find them. Veteran farmers can use this catalog as a source book for hard-to-find implements; novices will find helpful explanations of how to use these tools — the correct way to scythe, for instance.

The future looks bright for tool users and toolmakers in the gardening and small-farming field. Little imaginative thinking has gone into such tools in recent years because technology has been enamored with the concept of Big. But all sorts of interesting ideas await development. This book will help point the way.

0-87857-235-X



Tools for Homesteaders Gardeners and Small-Scale Farmers

A CATALOG OF HARD-TO-FIND IMPLEMENTS AND EQUIPMENT

BY THE EDITORS OF *ORGANIC GARDENING*®, *THE NEW FARM*®, AND INTERMEDIATE TECHNOLOGY PUBLICATIONS

Edited by Diana S. Branch

Rodale Press, Emmaus, Pa.

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I'd like to dedicate this book to my Grandfather who inspired me to learn the things which made my doing this book possible, and to my Dad who taught them to me.

D.S.B.
2/15/78

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Preface



Tools for Homesteaders, Gardeners, and Small-Scale Farmers is a technology sourcebook, not an exhaustive product listing. We want to show you what tools and implements exist to assist the small farmer and where they can be found. But, to be fair, we have to admit that there are many more sources of tools than we've been able to locate in the past year. If we missed a company you know about and trust, please let us know. If you are interested in distributing any of the products listed, we'd encourage you to write to the manufacturers. Many have expressed an interest in opening new markets.

It must be emphasized that the product descriptions in this book are not evaluations of the products. We are, in most cases, presenting the information provided to us by manufacturers or distributors. If we say more about one product than another, it is because somebody told us more about it. The same is true with photographs. We do not intend photographic coverage to be an endorsement of any product. However, we must confess to discriminating in favor of hard-to-find items both verbally and photographically.



Acknowledgements



Guidance in deciding what to include in this book came from three invaluable sources:

The idea for this book grew out of the Intermediate Technology Publications book, *Tools for Agriculture: A Buyer's Guide to Low Cost Agricultural Implements*, by John Boyd. Its object is to provide a source of information on the availability of appropriate tools for the people in developing countries. As the basis of this co-publication, Intermediate Technology Publications have gladly made their written and visual material available to provide the foundation for this book, to which a mass of further information has been added. As a result, the book should prove of inestimable value to farmers and smallholders, not only in North America, but around the world.

Agricultural Engineer, Dr. Biswa Nath Ghosh provided photographs and the technical groundwork for many introductory sections.

Gene Logsdon, a contributing editor for *Organic Gardening and Farming*, revealed many of the needs of the small farmer in North America based upon experiences at his own farmstead in Ohio and those of other small-scale farmers he's met along the way.

Many thanks to all those who contributed photographs and information to this book. Thanks also to the Rodale Press Photo Lab for assisting with the photographs.

My sincere appreciation to Barb Coyle who persevered with research, follow-up, collation, and keeping me organized.

Finally, special thanks to Jerry Goldstein for his guidance and support throughout.

—D.S.B.

Introduction

Finding the right tools can be the most critical need for a small-scale farmer or a large-scale gardener. It can mean the difference between staying on or leaving the land, between a sense of drudgery or a sense of fulfillment, between a successful harvest or a meager crop, between profit or loss.

This catalog will, we hope, help you to find and use the tools you need to produce food. The tools and equipment described in its pages were selected primarily for their value to the homesteader, truck farmer, and the small-scale organic farmer, but backyard gardeners should also find things of interest. This book attempts to fill the gap brought about by what the late E. F. Schumacher of the Intermediate Technology Development Group in London termed "the Law of the Disappearing Middle." As technology steadily moves to higher planes, we are left with primitive, simplistic tools on the one hand, and a very complex, sophisticated technology on the other.

This book intends to show that intermediate-scaled farming is one topic in which people of all lands share common interests and common needs. It is built on five important concepts which we believe to be true:

1. that in many instances the developing nations are ahead of the industrial giants in developing appropriate tools and machines for successful farming on a small scale;
2. that although it may not be readily available everywhere, the technology exists somewhere or has existed at some time in the past to accomplish those tasks which need to be done in an efficient way on the small farm;
3. that it is just a matter of implementing existing knowledge to get these tools to those people who want to put them to work;
4. that to satisfy the need expressed by the small farmer does not mean a technological regression to the primitive techniques practiced on yesterday's small farm, but rather a rediscovery of these techniques, a recognition that they retain relevance to today's small farmer;
5. that what is called for is a modernization of these techniques, applying the technological wisdom of today to the techniques employed in the past.

—Diana Branch, Editor

EXPLORING ALTERNATIVES

Innumerable groups and societies are now concerned with exploring alternatives—alternatives that do not destroy, waste, or pollute our natural resources. More and more individuals are dissatisfied with the mindless repetition of simple tasks imposed by mass production and are seeking greater self-fulfillment and freedom from the tyranny of superficial nine-to-five routines. The movement toward self-sufficiency, homesteading, organic gardening and farming, and natural food is a part of this whole movement.

The problems of agribusiness are also forcing us to explore alternatives. The problems are of both scale and technique: mechanized farming of vast areas with huge machines and widespread use of chemical fertilizers and sprays; the development of food factories; the massive infiltration of artificial ingredients into our foods; the intensive breeding of animals raised in confined conditions for slaughter.

Is more energy being poured into this type of farming than is produced by the harvest? Is the soil's substance being eroded? Do chemical sprays harm the environment more than they benefit the farmer? While surely we need the food, do the means we use to produce it destroy the resources on which we all depend? Are there satisfactory alternatives that could provide as great a volume of production using less-violent means?

These are some of the broad questions that are being asked by more and more people.

There are other related questions, too. As technology moves forward, machines become ever more sophisticated in doing the work of more and more people. In a period of rising unemployment throughout the world, should not this trend be reversed?

Certainly in developing countries, the planners and governments are beginning to have second thoughts. In many cases, the modern high-level technology that was introduced to increase productivity in various fields has proven disastrous for the countries concerned. Western-style technology used scarce supplies of capital and costly fuel, required maintenance beyond the ability of local skills, provided very little employment and even, in some cases, drastically reduced employment. Now, more appropriate alternative methods are being investigated by developing nations. These methods create more employment, use less capital, can be maintained by local skills, increase productivity by successive small increments, and are appropriate to the social and economic requirements of the particular country concerned.

Certainly, the time seems to be ripe for an examination of alternative techniques that could provide some solutions to the mounting concern that is being expressed. There are several lines of investigation that could be followed:

First, existing practices could be modified at the technical level in order to use renewable resources or modify machines so that less pollution is caused and less damage is done to the environment.

The second approach could be to revive and reintroduce an older, tried-and-proven technology using more labor, in which individual skills are needed, providing meaningful work and job satisfaction. These skills may have to be relearned and the technology and tools reworked to suit modern methods and materials.

Third, the scale of modern technology could be changed to meet the needs of a particular area or industry. Centralized production could be changed to small-scale production serving local areas rather than supplying several states. More employment would be provided, with less fuel being wasted on transport. Local preferences could then be catered to, for the establishment of a small industry in a local area has a multiplier effect on the local economy.

In a sense, this book is an amalgam of all three approaches with regard to agriculture and small-scale farming. It contains examples of many different tools and pieces of equipment that can be used in each stage of farming, from plowing to harvesting, from preparing the soil to processing the crop. Some of these tools are based on older, well-tried technologies; some are scaled-down, smaller machines designed for smaller farms; others are designed to use renewable resources to help make organic farming more productive.

This mine of information, carefully gathered and cataloged here, should prove invaluable to farmers, gardeners, and small landholders alike.

—Frank Solomon,
Editor, Intermediate Technology Publications

TOOLS, NOT MACHINES

Throughout the compilation of this book, we have selected the tool over the machine. The difference may be clear-cut in our minds, but not always so distinct in reality, since one and the same product may be a tool *or* machine, depending upon who is using it and how it is being used. A brush in the hand of an artist is a tool. The printing roller that duplicates his painting a billion times into a wallpaper pattern is a machine. There is nothing wrong with a wallpaper machine (though wouldn't it be better if we all decorated our own walls?) just as there is nothing essentially right about an artist's brush. But there is a difference. Peculiar things begin to happen when that difference is extended indefinitely in human activity. The tool remains hand-directed and unhabituated; the machine becomes increasingly more automatic and addictive if its power is not curbed. If you let go of the paint brush, it falls on the floor; the wallpaper machine will go on making wallpaper while you sleep. Because it is so easy to produce with a machine, we inevitably let it produce more than we need. The machine can produce an unlimited supply of wallpaper, but there is never a surplus of art.

Tools humanize; machines dehumanize.

Tools make unique products—each a little different from the other, each speaking eloquently of the tool's user. A machine deals in multiplied sameness no matter who or what operates it. The best machine operators are other machines.

The tool is fragile because it is individual. The machine is powerful because it is collective. In any contest where winning is measured in quantity, it is a mathematical certainty that the machine will win because it can always get there "the fastest with the mostest." As long as economics makes quantity the goal, the machine will devour the tool. And when all the tools are gone, the machine will devour lesser machines. For tyrants, the machine is the ultimate tool.

While our supplies of cheap fossil fuel last, farmers need machines to continue to wrest land away from other farmers for the ultimate aggrandizement of agribusiness. In the new technology, homesteaders, gardeners, and small farmers can live well with tools and have much less need for machines. But they need *lots* of tools.

The magic of any book, we believe, is in the possibilities it raises in the imagination of the reader. There are forgotten tools that could be made again—only better—and future tools not yet dreamed of. The ideas for them could spring from the obsolete tools of the past, so we have included pictures of farm tools from old manuals. Studying the anatomy of a 1930 tractor which is especially suitable to the needs of today's farmstead, a handy person just might be persuaded to build another one—or more.

There is a strong heritage, especially in the United States but elsewhere too, of the farmer as inventor. A large percentage of our inventors came from rural communities, and virtually all the industries which grew up in the United States in the 1800s started on a very small scale, often as one-man operations. Cyrus McCormick, Oliver Evans, Eli Whitney, even Henry Ford—each grew up on a farm. The inventors of tools we still need will most likely come from the ranks of today's small farmers—and their children.

Some tools now marketed for special purposes have uses for growers that the equipment makers didn't foresee. We've tried to include these tools whenever we've been aware of them. For example, a supplier of orchard- and fruit-farming equipment manufactures a mulch spreader for the commercial strawberry grower. The spreader can be placed on a wagon or in the back of a pickup truck. Straw bales are fed into one end and are chopped up and delivered out the back onto the strawberry plants. But the mulcher could be used to lay down straw or spoiled hay between raspberry rows, vegetables, or wherever the farmer needs it.

Common lawn and garden tools have uncommon homestead uses. A grinder-shredder will chop silage for cattle feed out of corn, pumpkins, mangels, or other plants. It will even grind a crude corn and cob meal for cows. A battery-operated hedge trimmer works fine for summer and winter raspberry pruning. A battery- or hand-operated sidewalk edger makes an adequate cutter for strawberry runners. A big ten-tined silage hand fork makes an excellent tool for handling mulching materials like shredded bark. The equally large hand forks we used to call barley forks, with tines closer together than those of a silage fork, are good for shoveling sawdust mulch.

Surely the future looks bright for tool users and toolmakers in the gardening and small farming field. Little imaginative thinking has gone into such tools because technology has been enamored with the concept of Big. All sorts of interesting ideas await development.

We hope this book can help point the way.

—Gene Logsdon,
Organic Gardening

-1- A Picture of the Small Farmer Today

SMALL-SCALE FARMING*

by Jerry Belanger

Pick up almost any issue of *Countryside* and read about the people who are prospering on small farms. Of course it's possible. We prove it every month.

But we're also careful to point out that it isn't easy. Not everyone who dreams of a small farm is going to make it.

Most farmers would be surprised to learn that anyone could be shocked by having their small-farm dreams shattered by an introduction to agribusiness. After all, everyone must certainly know that our farm population has been cut in half since the 1940s, and that the exodus is continuing even now. Everyone (and certainly anyone interested in starting farming) should be aware that only the larger and more-efficient farms are surviving.

If you haven't heard that wheat is selling for less than it brought in 1949, that cattlemen have been selling below the cost of production for more than a year and a half, or that dairymen have been skirting the same situation for several years, you probably haven't done enough homework to be ready to farm. If you don't know that the average U.S. farm encompasses 400 acres and represents an investment of about a quarter of a million dollars, and that the USDA predicts that it will take half a million dollars to break into farming by 1985, you might want to reconsider.

If that's the case, what are magazines like *Countryside* and *Mother Earth News* all about? Is it, as you ask, all a dream?

No, but let's get a few things straight.

To begin with, it's important to understand the distinction between homesteading and farming. If you're talking about producing your own food and preparing for the hard times ahead, that's homesteading. It can be accomplished on a large farm, a small farm, or in town, and since many people in rural homes do not produce their own food or prepare for the future, they are not homesteaders.

Farming, on the other hand, involves producing food for sale or barter.

In *Countryside* magazine as in the countryside itself, there is a lot of overlapping. Some of our topics cover farming, some cover homesteading, and many include both. If you want to be very technical about it (which we never are in the magazine), if you raise rabbits for your own table, you're homesteading; but the minute you sell a fryer, you're farming.

A chicken farmer, then, could be one who has 100,000 birds in cages in climate-controlled, light-regulated buildings . . . or it could be a person who sells a dozen eggs occasionally from the surplus produced by a backyard flock. It shouldn't take much imagination to figure out which one is going to produce eggs at the least cost.

This leads us to the fact that farming is a business. Obviously, you say . . . but it's not obvious to the dreamers. People who don't have enough business acumen to run a popcorn stand envision themselves as farmers, but it won't work. In fact, without knowing and adhering to business principles, even homesteading won't work! The difference, of course, is one of scale. The loss of a couple of dollars on a homestead can be written off as entertainment or exercise or education or any number of other expenses, but a loss on a farm is a loss, period.

This, perhaps, is at the heart of your concern, so let's examine it in closer detail.

* Reprinted with permission, *Countryside*, September 1977.

Any business, in any field, requires capital. You can't even start a lemonade stand without a lemon (or today, perhaps, a synthetic substitute). Farming takes thousands of dollars, depending on the location and type of enterprise. The average Wisconsin dairy farm today represents an investment of $180,000.

In the lemonade business, you'd probably borrow the lemon from your mother. She might not even make you pay her back and almost certainly wouldn't charge interest. But farm debts today stand at more than $1 billion, and those who lend that money expect to be paid back, with interest. Because they expect to be repaid, they examine the borrower's qualifications closely. If all you know about farming is what you've read in *Countryside, Organic Gardening, The New Farm,* and *Mother Earth News,* you probably aren't a very good risk.

So you need training and experience in the business. With the lemonade stand, you must know how to make lemonade, how to make a sign, how to select a location and a nice hot day, how to make change. Certainly no one would start a grocery or hardware store without knowing something about groceries or hardware, without making some type of market survey, and a great deal more. And if anyone thinks farming entails nothing more than buying some land, getting on a tractor, and going to it, well then yes, they're dreaming.

Will you raise cash crops or livestock? Will your crops be corn or soybeans, apples or celery, cabbages or artichokes? Why? Will you raise pigs or sheep or cows? Will your cows be beef animals or dairy animals, your pig enterprise a farrowing operation or a finishing operation or a farrow-to-finish operation? How much experience do you have in whichever you choose? How much capital will it take to get started, how long will it be before you can expect any income, how much money will you need to carry you through that period, what will your cash flow be, what kind of price will you need to make enough money to make a living, what kind of price can you expect in the future?

What kind of machinery will you need, and what do you know about buying, operating, and maintaining it?

And what about marketing? Is there a local market for your pigs or fat lambs, or will you have to ship them a long distance? Is the goat cheese co-op to whom you'll be selling milk established and well managed, or will it fold just about the time you get your herd built up? Or, if you intend to market milk yourself, how thoroughly have you investigated regulations governing such activity, how closely have you figured costs, just how certain are you of your potential market? If you sold a few gallons to the parents of a baby who's allergic to cow's milk, a guy with an ulcer, and a health food nut and assume that counts as valid market research, we can guarantee that you won't be farming very long.

All of this is only the rawest beginning, yet many people who dream of the countryside ignore even these most basic steps.

Now we come to the question of size. Is it really necessary to have hundreds of acres if all you want is a small farm?

Average size varies with location and type of enterprise. An acre of strawberries or asparagus near a major population center might be profitable; an acre of wheat probably would not.

In most cases, a small farm is at a competitive disadvantage if it produces the same products that a large farm in the area produces. The larger farm can make better use of labor and equipment and can more easily acquire operating capital. But we have seen some exceptions.

If a dairy farmer milks 100 cows with an average production of 10,000 pounds and sells that million pounds of milk per year at $9 a hundredweight, he grosses $90,000. The farmer who milks 10 cows of the same caliber grosses $9,000.

If both farmers had the same lineup of equipment, those costs would smother the smaller of the two. If the large farmer had large, fast, new equipment he would accomplish much more than the smaller one with small, slow, old equipment that constantly required repairs. But . . . there could be compensations. If the larger farmer's equipment and other costs were such that his expenses came to $85,000 a year, he'd only have $5,000 left. And if the smaller farmer could hold his costs down to $1,000 a year, he'd have $8,000 left.

A few years ago it would have been tough to find examples of this. New equipment was relatively cheap, there wasn't as much old equipment available, fuel was inexpensive, fertilizers and chemicals constituted a much smaller portion of the farm budget, land costs were lower, taxes were lower, and so forth.

But today, a new combine costs $40,000 or more: an older, smaller one can often be found for $100. Big farmers want—they need—8-, 10-, or 12-bottom plows costing thousands of dollars. They have no use for the old two-bottom out behind the shed, and they sell it for scrap metal prices. An average-size tractor (now about 85 horsepower) will cost more than $10,000; older, smaller models can often be had for under a thousand.

You'll have to be a mechanic if you own the old stuff, and you won't work as many acres in a day. But you'll get the job done. And you won't need nearly as many bushels or gallons or pounds to cover the cost of capital, to repay loans, and pay interest.

Large farmers are extremely shrewd managers. They have to be. They have large equipment because they know exactly what it costs them and what the alternatives are—and because they make money with it.

Small farmers have to do the same. A piece of equipment is not necessarily right just because it's old and small and cheap. Small farmers require the same type of management skills as large farmers; they only apply them differently.

There are several other angles here that can get us off the track. You, the reader, and I have a somewhat different view of the future than most farmers. For the most part, we believe in organic farming, and we're concerned about chemicals in our food and soil. We can see ecological webs that others ignore or are blind to. We are, perhaps, more deeply aware of the real meaning and nature of the energy crisis and its relation to food. We're uneasy about megafarming and disdainful of the middleman with his processing and packaging and advertising and hauling. We think that somehow this is all wrong and that we can make it right.

If you're serious about farming but lack experience, homesteading is certainly one of the best places to begin learning. Or, you might consider formal training and then working as a hired hand. With more experience, you might be able to farm as a renter or on shares. In all of these situations, you'll have to act like an agribusiness farmer, of course, unless you are fortunate enough to find organically inclined people to work with. It's getting easier all the time.

But perhaps the best alternative of all might stem from this encouraging note: fully two-thirds of all American farmers earn more away from their farms than they do from farming.

In organic and other ecological circles, this is generally taken as bad news. More than half the farmers of the 40s have been forced out, and only one-third of those remaining can be said to be full-time farmers. Ninety percent of our food is produced on ten percent of our farms. And yet, if part-time farming is actually twice as common as megafarming, isn't this a golden opportunity? If we can continue to earn a living in town, it doesn't really matter if the farm makes enough money to support us or not. We can learn. We can improve our land, build up our herds and flocks, settle in with machinery that's proper for each individual farm, build up equity, be organic.

It's not the ideal situation, because proper farming requires careful timing and full-time supervision and surveillance, but it's a darn good second choice. For most of us, it's the only logical choice. With study and practice, with good management and sound financial planning, a part-time farm can become a full-time one . . . and if our hopes that agribusiness can't last should prove to be right, such small farms will be in an extremely enviable position.

One thing more. Most organically inclined people know that it takes three to five years to convert a chemical farm to organic methods. But what many do not know is that many farmers believe that it takes five years, even for an experienced farmer, to get to know how to work a particular farm. Every place is different, every situation is different. This is yet another reason for the greenhorn to be cautious.

Yes, it's possible to make a living on a small farm. But it probably takes about as much training and preparation as a career in law or medicine or any other worthwhile profession.

SWEENY AMONG THE DALES

by James C. McCullagh

The Sweeny farm rests across a stream
past a huddle of pubs
and the newsstand in Brecon
which points a hurried finger at the green
and barren hills of Wales.
It is Sunday, when farmers never sleep
but slow down their chores
to take stock of their work
and the week to come.
I see the man Sweeny
moving back and forth
between barn and house
like a windmill.
He motions, like a policeman,
for us to come aboard.

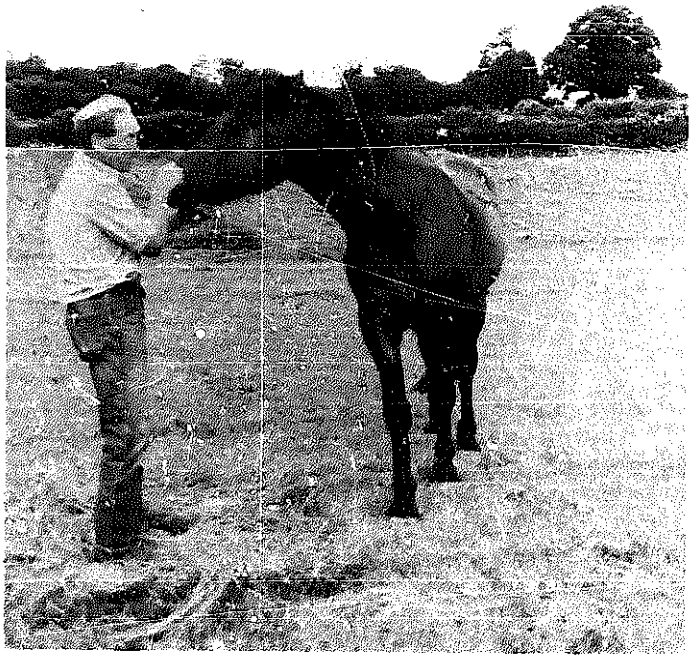
We walk up the snaking hill
like the ones the children draw so well
past the piles of steaming dung
to the courtyard where the ghosts of horses play
among the tools of the fields
graying yet hopeful of return to service.
In the pasture stands a mare
very white against the earth
that knows man Sweeny moves before she does.
"How old," he asks, "do you think she is?"
To be polite and safe I said, "Thirteen."
"Thirty," he said and cradled her
with brown and freckled hands,
feeling her still strong flanks
which have carved the rocky hills for years.
"Horses," Sweeny said, "used to work these hills
before we gave them to the sheep.
But horses are coming back.
I visit auctions up and down the coast
buying equipment for my stable.
Horses are coming back."

On the way to the car Sweeny showed us
a forge "from a local smith who died."
Among the hundredweight of steel,
the hammers and the tongs of silence,
I see a new fist striking the shoe
sending sparks across the dull Welsh earth
igniting fields of harvest wheat
plundered from between the reins.

FARMING IN WALES

by James C. McCullagh

In the absorbing hills of South Wales rests the ten-acre organic farm of Sedley Sweeny and his wife—a picture book farm, complete with Black Welsh Mountain sheep, an array of horse-drawn farm equipment, and compost piles that steam. But this is not Welsh acreage populated by romantics. If you want straight talk about the rigors of organic farming on inhospitable land, Sweeny is the one to go to. He is uncompromising in his advice; he minces no words.



Sweeny and friend.

Let the new farmer (or small-holder, as he would be called in Wales) ponder the following advice from Sweeny: "*hard, long hours* are inescapable, particularly when building up the farm and acquiring the essential skills. The alternative is to accept third-rate results, which, I feel, are the certain paths to failure. One must learn to find recreation in the ever-changing work and the rhythm of the seasons. More leisure should be possible later when the project is running well and one has achieved full co-operation with like-minded neighbors."

Sweeny, an ex-officer in the British Royal Engineers, bemoans the fact that until approximately "a century ago, a peasant child grew up on the land and learned the skills by his father's side. By the age of twelve, the rhythm of the farm life was part of him, and by fifteen, he could tackle practically every job on the holding. He accepted the hardships and joys of subsistence husbandry *because he had no option*. Today, our would-be small-holder jumps in at the deep end with the soft option of the welfare state waiting to rescue him if he fails to swim."

And Sweeny does not underestimate the skill farming demands. "Self-sufficiency farming," he notes, "probably requires more mental and manual skills than most other callings. In olden times, children learned their skills at their parents' knees. But now we have a whole new generation of young people divorced from the land and its traditional crafts. They have to learn from scratch; just like tackling a foreign language, one cannot expect fluency to come quickly to an older person."

While advocating the discipline of self-sufficiency, Sweeny does not romanticize the challenge. "A growing number of people," he remarked, "are opting out of our industrial-economic society in the hope of finding a new and true life of self-sufficiency on the land. The failure rate is high, almost always a result of inexperience and lack of the very considerable skills needed to produce, with certainty, a wide range of products necessary for survival. Our people have become soft and are daunted by the hardship that their grandparents accepted as normal."

Strong words, indeed, but Sweeny practices what he preaches. A center of farm activity is crop production. The three-year crop rotation is a variation of the traditional system used on mixed stock farms in upland Wales. Wheat and rye (one-quarter acre of each) for home milling are autumn-sown by fiddle direct on the inverted sward. Crops are cut by scythe, bound by hand, and placed immediately on tripods to dry and harden. If the crops are carted in time, Sweeny reports that he turns "the hens onto the stubbles for up to a fortnight before cultivating with spring tines. We then sow a crop of grazing oats or rye to provide an early spring bite for house cows."

Sweeny reports that the ground receives a liberal dressing of compost in February or March which is plowed in not more than four inches deep. The ground is then cultivated with spring tines and harrows until a good tilth is obtained. It is then ridged, using a single-furrow horse ridger. Three rows of main-crop potatoes and one-fourth acre of mangolds are sown on the ridge in early May. A single row of peas may also be sown. In late May, a double row of main-crop carrots and in early June, about one-fourth acre of seeds are sown."

According to Sweeny, the dredge corn crop is cut rather green using a scythe of a tractor mower. It is not bound, but put immediately onto a Tyrolean-type three-wire fence so it dries like hay. On the fence, it is quite safe until carted.

Approximately three acres of grass are made into hay. If sufficient material is available, the fields are composted, harrowed, and rolled in mid-April and laid up until cut in early July. The hay is cut with a tractor mower, turned with wooden rakes, put onto tripods, and carted loose when ready.

The individual paddocks are grazed hard by cattle and sheep for five days and rested for up to three weeks, thereby improving the sward and reducing the incidence of intestinal worms in the stock.

Sweeny states that "all grassland is treated with calcinated seaweed, two hundredweight (cwt.) to the acre once every three years; it has also had one dressing of basic slag at ten cwt. in 1975 which has already caused a remarkable growth in white clover."

The Sweenys' one-quarter-acre vegetable garden, in which the crops are rotated on a four-year cycle (potatoes, pulses, cabbage family, roots, and onions), provides practically all-year-round fresh vegetables for the house plus a surplus for sale at the farm gate during the summer. And to extend his season, Sweeny uses an attached greenhouse for early seeding. In fact, he has discovered that he is able to grow tomatoes year-round in his greenhouse, which is quite a feat in Wales where light intensity and sunshine levels are low.

Contrary to how it may seem, Sweeny does not consider his farm a haven of self-sufficiency in a hostile world. He notes that "I am sure that a family could survive on its own in complete isolation, but this would be a rather uncomfortable and insecure subsistence. Three or four neighboring smallholders, working in harmony and pooling their individual skills could live far better. Add a bit of modern technology and life becomes easier, with more leisure time, less drudgery."

And communality is a central feature of the Sweeny experience. For example, his flock of Black Welsh Mountain sheep, consisting of a ram and twelve ewes, graze the acreage on a hillside opposite the farm and are tended unofficially by Sweeny's neighbor. In fact, a spirit of operation seems to pervade this Welsh farming community.

Sweeny acknowledges that when he has hay to cut, he simply has to call his friends. And when he has a sheep to shear, a building to construct, or any formidable task, he does the same thing. And his neighbors do likewise. He is presently equipping a forge, obtained complete from a smithy in the nearby village, which will serve as a communal workshop for him and his neighbors.

Not unlike some farmers in the United States, Sweeny spends some of his time visiting farm

auctions, always on the lookout for good, used farm equipment which will serve his needs. This way he is building up an impressive array of horse-drawn equipment for the time when his farm will be plowed, cultivated, and harrowed by horses which, according to Sweeny, "are part of the Welsh hill tradition."

Sweeny senses a genuine back-to-the-land movement in Britain, something he doesn't necessarily greet with open arms. He firmly believes that people, if they are to be successful on the farm, must receive solid training for the job. Accordingly, he hopes to encourage some British agricultural schools to initiate a formal apprenticeship program for would-be farmers. A number of schools have shown considerable interest in this program.

For his part, Sweeny has an apprentice on his farm who is learning the ropes from the ground up. Sweeny emphasizes that "experience comes only with the time, and I would suggest an inexperienced youngster would be unwise to attempt subsistence farming until he spent two years working on a good, mixed farm."

Not everyone would agree with this approach to farm education. However, few, I think, would argue with Sweeny's success. And if you would like to learn more about this fascinating farm in Wales, write for a booklet entitled "Self-Sufficient Small-Holding," which can be obtained from the Soil Association, Walnut Tree Manor, Haugley, Stowmarket, Suffolk, England. Price, $1.

AVI—A VILLAGE CONCEPT

by William R. Lawson

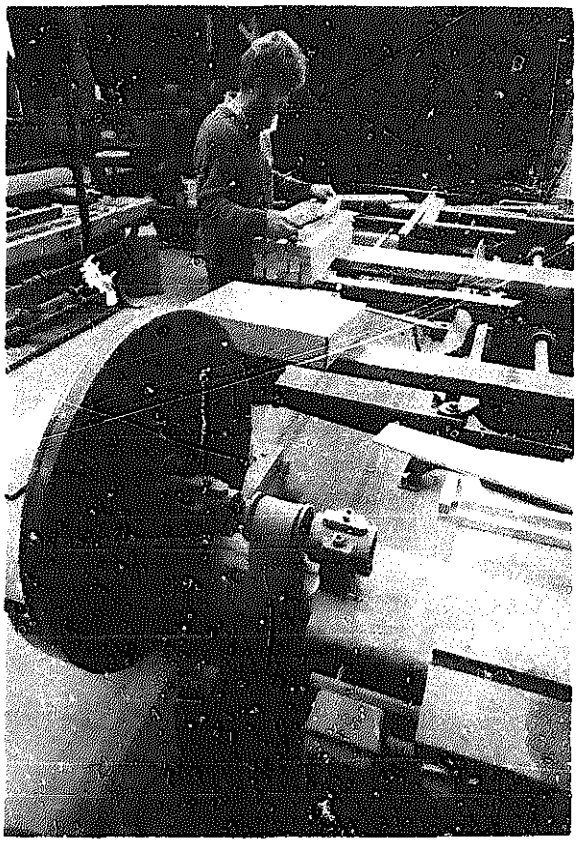
Editor's note: The American Village Institute, teaching the dying skills and concept of self-sufficiency, is a source of hand- and foot-operated tools made from traditional designs and materials.

In many ways the American Village Institute is perhaps the most unusual nonprofit research and educational organization currently active in the field of alternatives. Young, but rapidly growing, the AVI was begun in early 1975 by a small group of dedicated "villagers" who saw the need for a comprehensive institute entirely devoted to teaching people how to become more self-sufficient. Not just to be self-sufficient individuals, but also how to create reasonably self-sufficient communities. It is this emphasis on small-community—or village—development that lies at the heart of the AVI concept.

In order to fully understand the objectives of the AVI, it is first necessary to understand what is meant by the term "village." In brief, a village is defined as a simple composite of family farms, tradespeople, and a marketplace. It is further distinguished by the fact that most of its inhabitants can and do provide most of their own basic necessities, and at least some of their niceties. It is also perhaps the largest form of socioeconomic grouping that can still function entirely on the basis of trade, barter, and the exchange of labor.

With this definition it is easy to see how the village concept can provide a very useful framework for exploring the entire area of self-sufficiency and appropriate technology. By using this village approach, the AVI is developing a broad research and educational program that has many innovative features. One of the most important of these has to do with the study and design of appropriate tools and equipment, and the teaching of the skills necessary to make and use them.

To begin with, the Institute is mostly interested in the development of those tools and methods that are ordinarily associated with traditional crafts, trades, and skills. The reason is simple: no one can be any more self-sufficient than if they can provide their own food, clothing, and shelter, as well as their own tools. [Prior to the industrial revolution that is exactly what most people did—at least within the village structure.] At the same time, the best way to learn these skills is to study them under the guidance of someone who has already mastered them. With this in view, the AVI has begun a comprehensive apprenticeship program that encourages each student to master at least one craft or trade,



An apprentice at the AVI workshop.

and gain at least a working familiarity with all the skills necessary to provide the basics of food, clothing, shelter, *and* tools. Although still in the initial phase of development, it is envisioned that each student who completes the entire course will have the knowledge and ability to create a very comfortable, yet highly self-sufficient way of life.

This focus on tools and related technology is not accidental. In fact, one of the primary reasons the AVI was established was because there were no longer any sources for many of the hand- and foot-operated tools and equipment common to rural America up until the 1940s. The object from the beginning was threefold: first, to make available many of these items that have faded into the past (or are collecting dust in antique shops); second, to reintroduce a new standard of quality in design, craftsmanship, and materials; and third, to provide a reliable method of funding for an apprentice-style craft and trade school. Specific products have not only been selected because of their traditional use, but also because they require a broad range of crafts and skills in the making. They also reflect the type and range of products many students will begin producing once they have established their own shops.

In addition to making traditional tools and equipment, the Institute has also begun to develop many of the older methods and processes that were originally used to make these tools. This begins with the basic methods of extracting and refining raw materials and carries through to the last touches on the final product. For the most part, the emphasis is on the use of hand and foot power—though there is also an attempt to recreate and/or improve upon earlier uses of water, wind, and animal power. This work is aimed at developing a contemporary version of all the tools, hardware, and technology that were typical of an average early American village—as well as the knowledge and skills necessary to use them. The object is not to recreate the past out of curiosity, but rather to regain much of what has been forgotten and integrate that knowledge with what is being learned today.



Three of the implements manufactured by AVI (left to right): a cider press, a corn sheller, and a root cutter.

In addition to the apprenticeship program, the Institute is also developing a more general course of instruction in applied (appropriate) technology. This program was scheduled to begin in early October 1977 and to include a variety of subjects ranging from organic farming to the design and construction of energy-efficient architecture. The emphasis is on teaching the underlying principles upon which all technology is based, and how to apply those principles in the development of contemporary village-scale communities. The Institute is also beginning publication of a series of technical (how-to) manuals that will cover all aspects of self-sufficiency at both the family and village levels. Other publications, like the Institute's bimonthly magazine *The Cider Press*, are intended to provide a more general view of how self-sufficiency can be related to a contemporary village structure.

Perhaps one of the most unique features of the AVI is its growing membership program. Based on the belief that more people will become self-sufficient once it is technically and financially easier to do so, this program offers members the opportunity to contribute their own time, energy, and talents to the overall AVI effort—and in return, receive all the benefits that this combined effort can produce. In many respects this cooperative approach allows individual members to get back considerably more than they put in. It also dramatically increases the effectiveness of the entire organization. For example, the apprenticeship program is open to all members tuition-free (including room & board); in turn, the products made by the apprentices during the course of their training are available to the general membership for the cost of producing them (no profit is added). This serves the dual purpose of providing free training for those who desire it, and highly crafted, exceptionally low-cost tools and equipment for those who need them.

The membership program also provides a much-needed outlet for the many creative people throughout the country who would like to become involved in Alternative research and education, but have been unable to find an organization that can translate their energies into constructive projects. Much of the Institute's research, as well as material for publications, comes from the more than 3,000 members in the United States and many foreign countries. Participating members from many universities, industries, craftshops, and farms across the country provide the Institute with a steady influx of valuable research information, suggestions, and ideas. In fact, many of these people have since become permanent members of the Institute's faculty and staff.

In brief, the village concept has begun to excite the imagination of people everywhere, in every walk of life. It not only provides a framework for the development of appropriate tools and technology,

but also promises to become the most direct way for many people to achieve a greater level of control over their basic needs. By working within this concept, the American Village Institute has begun to create a new direction that can get people involved in a very meaningful way. Because of this co-operative approach, the AVI has become a powerful catalyst for change.

MACHINERY ECONOMIZING AND ANTIQUING ON THE SMALL FARM

by Rosalind Cich

Schuyler and Rita Case are self-sufficient farmers from Sharon, Wisconsin. The Cases typify a special breed of small farmer in the United States today. They have farmed all their lives, both having grown up on Illinois farms.

Schuyler Case explained their farming operation: "The two of us work our farm alone. We have 85 head of Holstein cattle, 30 for milking. Our milk has been purchased by a local co-op for more than ten years. Our corn and soybean crops are sold through the local elevators. We grow oats and hay for our own animals and sell what's left." To supplement this internal farm income, Case does a little custom silo filling.

Case feels their farm has several advantages over much larger operations: "Because I have a fairly small place, I can plow using one of the 45 horsepower tractors that I bought 22 years ago. With that and my newer 70 horsepower one, I can cut costs. Sure, I only plant 15 acres a day while my larger



The Case farm: a new home for orphaned machinery.
Gerald Cross

neighbors are plowing 75 to 100 acres with their 150 to 200 horsepower tractors that cost $30,000 to $50,000, but some of those farmers will never be out of debt. They are working for the bank."

"Not only that—with these older tractors, you just add gas to them and four new spark plugs and they'll run. With the new fancy tractors, you need an engineer to overhaul them if something goes wrong. I'm not condemning the farmer who wants a $50,000 tractor with a cab top; I'll just stay out of the fields on those windy days."

"We've learned many different ways to cut costs," said Rita Case. "We cut our grain with a 45-year-old McCormick-Deering eight-foot grain binder we paid $5 for five years ago. We found it in a machine shed on a farm. It was in such good shape that it still wears its original coat of paint. Since we've had it, all we've repaired are the sickle and reel on it, which were both minor jobs."

"Because I've gotten a reputation for collecting old machinery," interjected Case, "I've been able to accumulate some parts through dealers. The ones who've been in business a long time are often excellent sources of old parts for old machines. One, who had no use for the old pieces his company had been storing, gave me a large quantity of them, like sections that go in the sickle of the grain binder. I also buy and keep some machines that are not operable, solely for their parts."

Mrs. Case added, "We realize that no old machine does the job as well as its modern counterpart does. The old equipment took time and labor, and the modern machines take much less time, but they are also much more expensive. Schuyler cuts grain with that old binder. There's a lot of labor involved, because then the grain has to be put through the threshing machine, whereas with the modern combine, one man can do it all with almost no help."

"Although we generally farm modern, we thresh ancient as a hobby," Case noted. "Each year we hold a thresheree on this farm. People come from all over. Many of them have never seen a steam engine before. Our Advance 1910 steam engine weighs 20,000 pounds, and you have to start it at 8 A.M. to get up the steam. We build a fire with wood until we get a full head of steam. Then we start pouring on coal for greater heat, while its black smoke beckons the neighbors. With 125 pounds of steam we can start threshing as long as we stoke the fire and keep the 225-gallon water tank full."

Rita Case smiled, "Our thresheree is a real show. At least 500 people come every year in August. Sometimes we have as many as 1,000. Most of them come primarily to spectate, but many help. Last



Weighing 20,000 pounds, the Advance 1910 steam engine supplies power for threshing. Gerald Cross



Many volunteers make light work of collecting hand-bound shocks.
Gerald Cross



In action, the belt-driven Belle City 28-inch thresher.
Gerald Cross

year, a lawyer from Milwaukee (more than a 90-minute drive) pitched bundles for three hours. Some work all afternoon, others for 20 minutes. Last year we threshed all afternoon, finishing 12 acres. After we thresh, we have a large dinner to which we invite 100 local people and friends. Everyone brings something. The *Milwaukee Journal* even came to cover last year's event."

The Cases use several machines for threshing. "We have a Belle City 28-inch thresher which is powered by our Advance steam engine. We also use 1932 Case and L. John Deere tractors to pull the wagons. The Case is a C Model, 2-plow, 35 horsepower, and the Deere is 18 horsepower."

"I don't know if you realize that in threshing, the grain is shocked by hand in old twine; you have to use old binder twine because modern baler twine is too heavy. All year 'round, we keep our eyes open for old binder twine at sales. It's still good for use as long as it's been kept inside and dry. Recently, we bought some that was packed in the original bags it came in."

Case continued, "Some of the things we have are too valuable not to take care of. Some of them someday may be more valuable than the enterprise we make our living at. The farmer down the road sold a tractor he bought 35 years ago. He's used it all these years and has taken good care of it. He sold it for $1,100; that's more than he paid for it new. I have two Allis-Chalmers WD 45 tractors that I bought new for $2,200 apiece, 22 years ago. I use them all the time. Even so, right now they're worth $1,200 to $1,400 apiece."

"I have a one-row corn binder in excellent condition. It's a real good one, 35 years old. I would like to use it as a fun thing but it only does one row at a time. It ties the corn into bundles; then they have to be picked up and put into a wagon. Using this machine, it would take ten men to fill a silo in one day, so I just can't spare the time to use it. The one that I use instead is five or six years old, and 110 horsepower. It does two rows at a time; using it, two men can fill a silo in one day. In other words, I don't use old equipment if it's not reasonably efficient. My time is important to me." But, many times older equipment does a perfectly good job.

"I use a hay mower and conditioner that are 15 years old. They're hooked together and pulled with a tractor. My mower is a seven-foot International. My New Idea hay conditioner crimps the hay to dry it sooner. The modern machine that does their work is called a hay bind; it cuts a swath ten feet wide and crimps the hay at the same time. The new machine costs at least $4,000, while my two when new ran about $2,000 together. You could buy used ones for about $500 per pair. Think about it; they're 70 percent as efficient as the new machine. They even have the same operating speed. To me, there's not too much advantage in having a new hay bind."

Rita Case mentioned another machine which could save money for a small farmer: the small

tractor-pulled combine. Case elaborated, "From the thresher, the farmers went to a small combine that one man could pull with a tractor with power take-off (a two-plow tractor, 40 horsepower). A man could farm 150 acres, if he wanted to economize, with one of these. As far as I know, they haven't been made for at least ten years, but one of our neighbors bought a nice one at an auction. It's 20 years old, in good condition, can be pulled with his tractor, and cost him around $500. If he'd purchased a modern self-propelled combine, new, they start at around $26,000 and go up to $50,000."

Case talked about another used piece of equipment that the small farm could find valuable. "The Allis-Chalmers G Model tractor is not the kind of machine for a large crop farmer, but I hear they're very useful for the small vegetable farm. The motor's in the back, and they cultivate one row at a time. Most of the ones I see for sale are about 25 years old, but I hear they can be used for so many different jobs that they are handy to have around."

Rita Case offered some tips on collecting antique machinery. "We don't ever go to antique auctions. The prices are too prohibitive. Instead, we attend family farm sales, and a lot of times find pieces in fantastic condition. Of course, all our friends tip us off when they hear about something we would like to have. Also, sometimes we stop at farms when we see interesting pieces out in the yards. We have a 1929 McCormick-Deering 1020 tractor; we are its second owners. This is its first time off the original farm. And we have an old clover hauler in 100 percent working order. There's even a 1929 steel-wheeled tractor Schuyler cuts grain with."

Schuyler Case added some advice on picking out old machinery. First, he pointed out that the machine in perfect working condition should be efficient in its use or it will be a worthless farm addition, as is his one-row corn binder, which is valuable only as an antique.

The second thing he stressed is that the shopper must use his or her mechanical knowledge to check out the machine. Case pointed out, "Remember that the old machinery runs with chains and gears, whereas the modern ones run with pulleys, bearings, and belts. Those parts make modern equipment run smoother. It's an altogether different method of working."

"You can tell if a gear or a chain is worn out; you can tell if it's good. Use your knowledge in dealing with and repairing other machines to pick out and evaluate farm equipment. Then you won't have any problems. Just keep your eyes open and your ears cocked, and you'll hear of all sorts of useful things that are available. Sometimes we drive hours to look at just one piece."

"That's so true," commented Rita Case. "It's become our major form of recreation."

HOW TO BUY AT A FARM AUCTION

by Kennedy P. Maize

You can buy good used homestead tools at very low prices at auctions. Often you can find tools there that you can't find anywhere else.

In the course of a single year, I've purchased the following items at the following fantastic prices:

- A 20-inch Sears chain saw for $9;
- A 7.6-horsepower Gravely tractor with electric starter for $200;
- A perfect scythe, including snath and grass blade, for $8;
- 35 one-pint fruit boxes for $2;
- An assortment of digging irons for $3;
- A five-gallon metal gas can for $2.50;
- A brand new four-drawer full-suspension file cabinet for $30.

I've seen a wide variety of tools and equipment sold at country auctions—cyclone seeders, corn shellers, spokeshaves, nippers, blacksmith tongs, horseshoe nails, grain cradles, and wire strippers—in short, enough good stuff to equip a homestead several times over.

Beyond simple economics, farm auctions are a common form of entertainment and socializing. Going to auctions is a good way to equip yourself, and a fine way to meet nice folks who share some of the same values you do.

A word of warning here—in fact, several words. I'm talking about farm auctions, not antique auctions. It is usually easy to tell the two apart, because auctions are advertised in the local papers and the ad should provide the clue.

For example, an ad appeared in our local daily recently that read like this:

PUBLIC SALE OF FARM EQUIPMENT

Selling for Price Farms, Rodney Dill, and Mr. and Mrs. Jake Scheller on the Robert Mullendore Farm located ten miles south of Hagerstown on the Boonsboro-Williamsport Road four miles west of Boonsboro, and two miles east off Sharpsburg Pike at Lappan's Crossroads on:

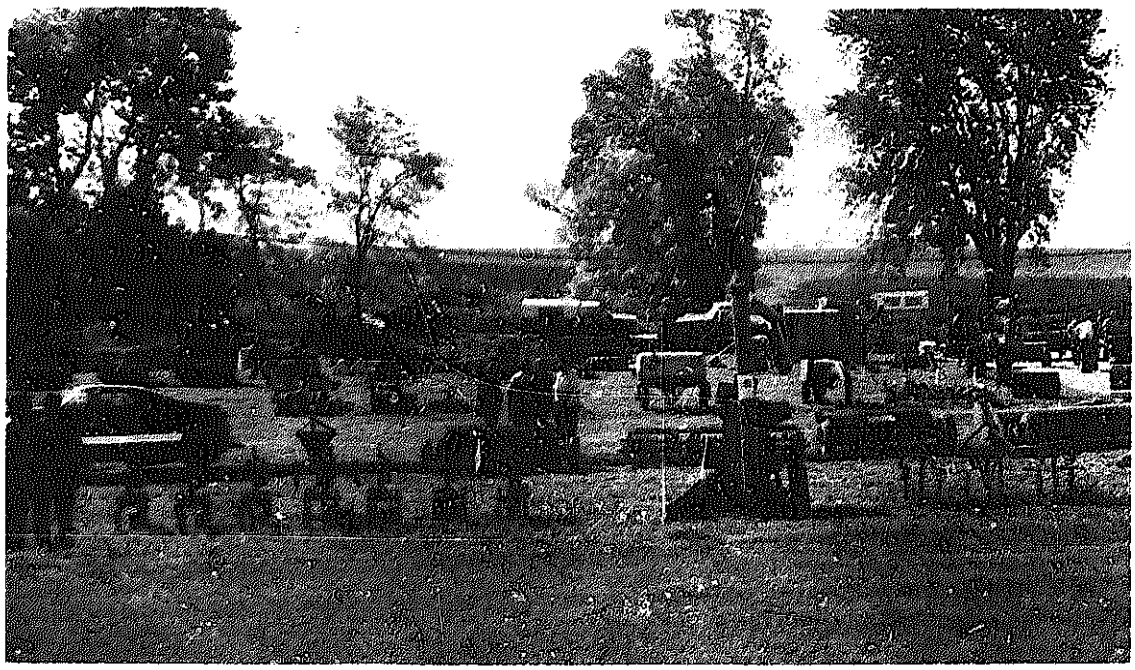
FRIDAY, FEBRUARY 13
at 10 a.m.

11 TRACTORS AND FARM EQUIPMENT

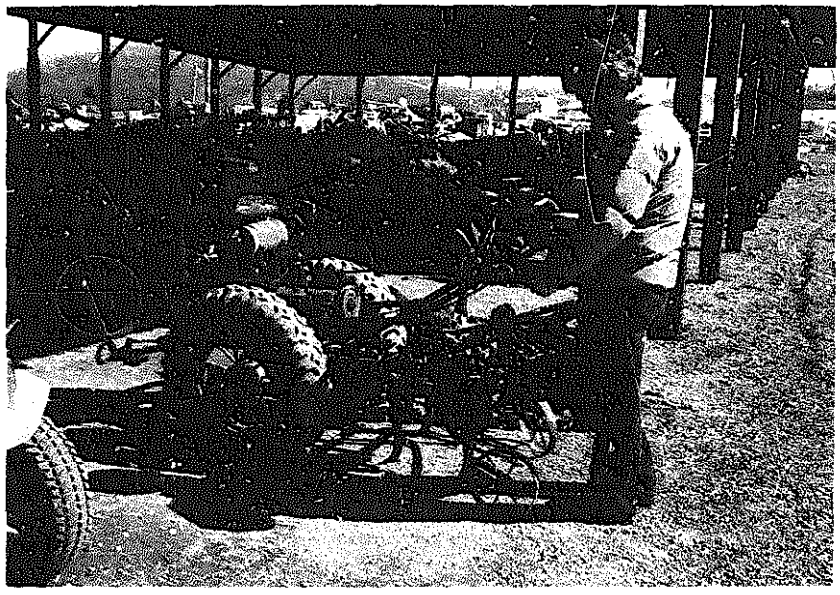
John Deere 5010 turbo; JD 4520 diesel w/1400 hrs; JD 4020 diesel w/power shift; JD 4020 gas; MF 165 w/loader; M. Harris 44, two JD A's, Farmall H w/loader; M. Harris 22, cultivators, and two-bottom plow; Ford 8N w/loader; two JD #38 forage harvesters, corn and pickup heads. . . .

And so on for some six inches of small, dark type describing an assortment of farm machinery including some nice horse-drawn equipment and a wide assortment of hand tools.

That is a farm auction. These ads frequently begin with a poignant phrase such as: "Due to quitting farming, I will offer the following at Public Sale located on the premises."



Second- or third-hand tractor attachments can often be picked up at reasonable prices at farm auctions.



Great "finds" can be made at auctions, though some oil and elbow grease may be needed to get parts moving again.

In these parts, the small family farm is a dying institution. Except for a few hardy souls and a sprinkling of crazy homesteaders like us, young folks leave the farm as soon as they can. Surveyor's stakes sprout in the fallow fields, soon to be followed by the early signs of suburban subdivisions. It's a familiar, tragic story. But it puts a lot of equipment on the market for the careful homesteader.

You want to stay away from antique auctions, though. Be wary of auctions that advertise a lot of old guns, coins, or glassware. Prices at those affairs run high and are frequently unpredictable. I've seen a corn sheller worth no more than $10 go for $25 because an antique lover wanted to make a lamp, or a toilet paper holder, or something like that, out of it. So be careful at these kinds of auctions.

Care, of course, is a necessity at all auctions. I'm going to give you six tried and true rules for auction buying which should guarantee getting your money's worth at auctions. But before we get into that, there are some preliminaries you ought to know if you are planning to frequent auctions.

First, almost anything can be, and is, sold at auction. In the case of farm auctions, that means everything including land, houses, livestock, canned and frozen goods, equipment, and clothes. Some time ago I went to an auction where a lovely 15-acre piece of mountain with a fine old stone house was sold. Included in the list of items for sale was a Home Comfort wood stove, a forge in good working order, a shelf full of canned cherries, and a complete World War I Army uniform, right down to the puttees.

If you decide you want to buy something at an auction, keep in mind that most require payment in cash on the day of the sale. This usually permits payment through a local check, but it is a good idea to call the auctioneer beforehand. His number is usually listed in the ad. In the case of big items, such as land, houses, and heavy equipment, the full-payment requirement is usually modified. In these cases, the auctioneer generally wants ten percent on the day of sale and the balance within 30 days. This, too, is frequently specified in the ad.

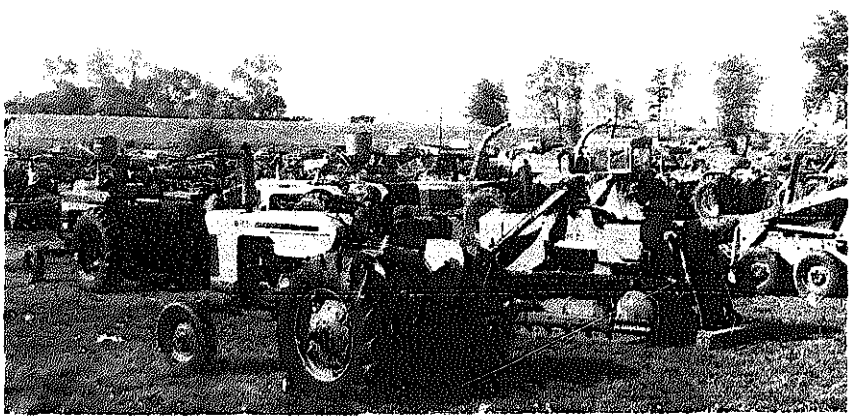
Sometimes the ad will also specify the bidding system. The most common bidding system at farm auctions around here is the number system. The bidder registers his name and address with a clerk on the site. The clerk will then give the bidder a number on a card. Sales are recorded by the numbers of the successful bidders. It's a good idea to record your purchases on your card as you bid, so that you can compare your record with the clerk's when you pay.

With these preliminaries in mind, let's move on to the six rules of buying at auction. I'll illustrate the rules with the story of the chain saw I bought for $9.

Rule number one: know your needs. I needed a chain saw. My ten-acre place has a three-acre woodlot, and another 5,000 acres of hardwood forest surround me. My three wood-burning stoves supply a large portion of the winter heat. I needed a chain saw but didn't have $250 to put into a good-sized new saw, and I wanted more capacity and ruggedness than a $100 minisaw could provide. The point to the rule is to avoid impulse buying at auctions, right from the start. Generally, impulse buyers end up paying more for less. At auctions, an unwary buyer can end up getting far less for far more than anywhere else I know. So, start right by disciplining yourself to know what you need when you read the auction ads.

Second: know the merchandise. This doesn't mean you have to become a manufacturer's representative for Homelite if you want to buy a chain saw. It means you should make some effort to discover the basics of the product. It is enormously helpful to know new models from old ones, good models from bad ones, and safe ones from dangerous ones. So I did some research. By talking to some folks who use chain saws every day, including a man who makes his living felling trees, I learned some valuable product information. I was ready to make intelligent decisions about brands, models, features, and the like. I knew the merchandise.

The third rule is related to knowing the merchandise: know the market. Find out how much the new product sells for and how it depreciates. This also requires a little research. I talked to the dealers, read classified ads, and generally shopped around. I discovered that I could expect to pay a retailer about $90 for a five-year-old saw in good working order. Now I was prepared to make a realistic auction bid.



Know your merchandise—original cost, present retail price, depreciation. Will it satisfy all your needs? If you're planning to buy a tractor, be sure to get there before the bidding begins, to start it up, look for oil leaks, and kick the tires.

The first three rules involve processes that occur before you get to the auction to bid. The last three involve decisions you must make at the auction. Once you have identified your needs, done some product research, and analyzed the market, go to the auction and inspect the merchandise. That means getting to the auction early. I read an ad in the local paper that listed a "Poland" chain saw among the items for sale. I was interested and showed up before the bidding began. The saw turned out to be a late model Poulan with a 20-inch blade. It was in good condition. I looked at it carefully, started it, and checked to make sure the blade was straight. I took the spark plug out and looked at the deposits on the electrodes. Remember rule four and inspect the merchandise.

Everything about the Poulan was fine, except the bidding. There were others interested in the saw. The bidding started at $50, I got in a bid at $60, and the price was up at $100 before I could nod again. I was tempted, but I stayed out after it passed my limit of $95. That is rule five: set a limit.

The limit is important because there is a psychology of auctions. The auctioneer, an agent for the seller, is trying to get the highest price he can for an item. He usually has a sound knowledge

of what an item is worth. He tries to get the bidders to compete for the sake of competition and to lose sight of the intrinsic value of the item. The auctioneer hopes to make the chain saw a symbol of victory in the contest, rather than a tool for cutting wood.

Those old situation comedy scenes are accurate. People do get so involved in the bidding that they forget the worth of the merchandise. I saw it happen recently. I had gone to a farm auction to bid on some rolls of American wire. The wire was selling in the Sears catalog for $35 a roll. I had the page from the catalog with me. The auctioneer tried to open the bidding at $50 a roll, came down to an opening bid of $20, and when I left, the price was up to $40 a roll and still moving. You have to set a limit and stick to it. Otherwise, you are going to pay double—once for the merchandise and once for the fun of bidding.

Those five rules—know your needs, know the merchandise, know the market, inspect the merchandise, and set a limit—are adequate for most auction situations. The likelihood of disaster is minimal if you follow them. However, the chance of getting a fantastic bargain is also less than it might be. The final rule will permit you to seize a situation and make a score. It's simple: be flexible.

Don't abandon the first five rules. That's why I put them first. If you follow the first five, you will be adequately prepared to be flexible. It is the person who has learned flexibility without discipline who gets into trouble.

The conclusion to my chain saw story illustrates the importance of flexibility. While looking at the Poulan, I noticed an elderly David Bradley saw for sale. It had a 19-inch blade and didn't run. I looked closer. I'm not much of a mechanic, but I discovered part of the problem. There was no fuel line running from the tank to the carburetor. But there was oily sawdust around the blade and chain, and there was no rust anywhere on the saw. It was obvious that the saw had been running recently. The saw was heavy but well balanced and offered secure grips in all attitudes. I decided to bid up to $25 for it.

The auctioneer tried for a bid of $20 to open, but couldn't get it. I bid $5; someone else said $6; I said $9. I got it.

A piece of rubber gas line, a set of points, and some minor carburetor repairs, and the saw was running. It has been running ever since.

I got the saw because I was flexible and ready to run a risk. But it was a prudent risk, because I followed the rules of buying at an auction. The risk was calculated, based on a pretty good idea of what I was getting.

And now you are prepared to shop at local farm auctions. If you know your needs, know the merchandise, know the market, inspect the merchandise, set a limit, and are flexible, you will come out ahead. And you'll have a lot of fun at it, as well.

-2- Tools for Cultivation

The most important reason for cultivating is to prepare a firm seedbed. When seed is placed in the soil, the dirt should fit around it snugly, so that moisture is readily available to germinate the seed. If a seed is dropped among clods, it will just lie there until rain falls. If a seed is dropped among loose, partially broken clods, the seed may germinate and sprout, but then the seedling dries out and dies if rain doesn't fall.

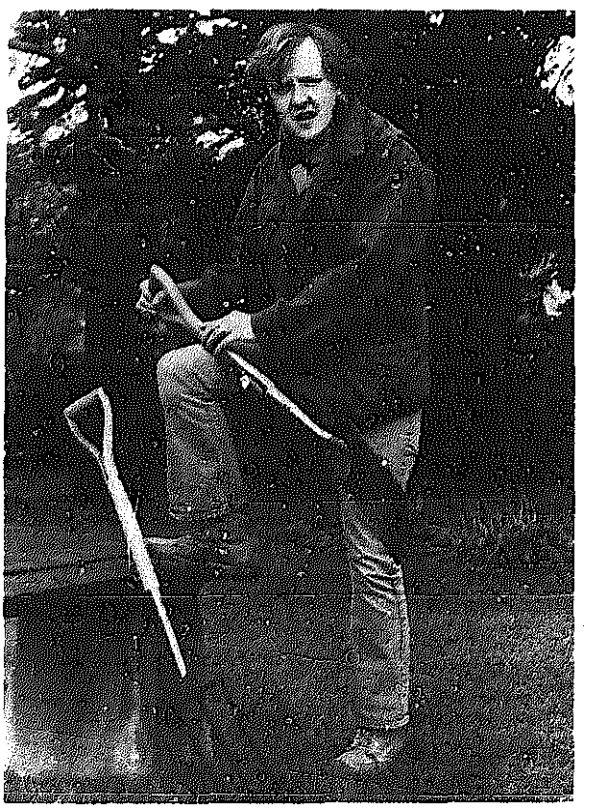
A second important reason for cultivation is weed control. While cultivating for weed control, the soil benefits by being loosened for better aeration and drainage.

When to cultivate is usually the most difficult lesson for the novice gardener or farmer to learn. Soil moisture and temperature are the two gauges to use in determining the proper time to work soil—when the soil is fit, as a farmer would say. Of these two considerations, soil moisture is the more crucial—if soil is worked when it is too wet, especially clay soil, it will become too hard for plants to grow through easily.

HOES

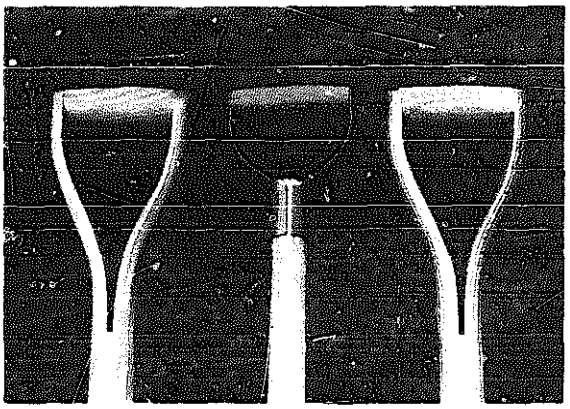
MASTERING THE LOWLY HOE

by Hank Allison



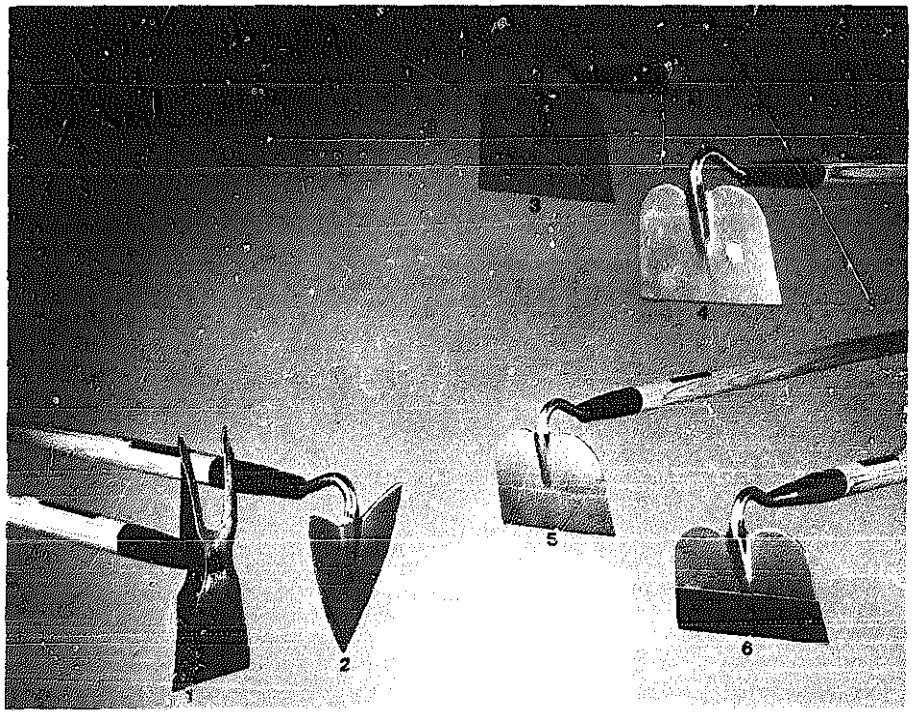
Anybody who spends much time working a garden by hand will have a real need and appreciation for quality hand tools. The best part about buying good hand tools is that they don't cost that much more than cheap tools, and they'll last you a very long time. If you don't like your rotary tiller, you can still use it because you'll only need it a few times a year but if you don't like your spade, you have a real problem. When buying hand tools, look for quality and a piece that is of the proper proportions for you—something that will work with you not against you. Put on your work clothes and do some spading if at all possible before you buy the spade. It's just like buying shoes—if they don't fit your individual needs, you'll never use them, no matter how much they cost.

Doing battle with the weeds calls for the right tool, the right chopping method—and the right mental attitude. The right tool should be lightweight, of a handle thickness that's comfortable to you, and a length appropriate to your height. It should be just long enough for you to grasp almost at the end and still be able to stand nearly upright and chop. The longer the handle, the less your leverage on the blade. Keep the hoe sharp. A 45-degree edge slanting toward the handle will make efficient use of your labor and a longer-lasting edge.



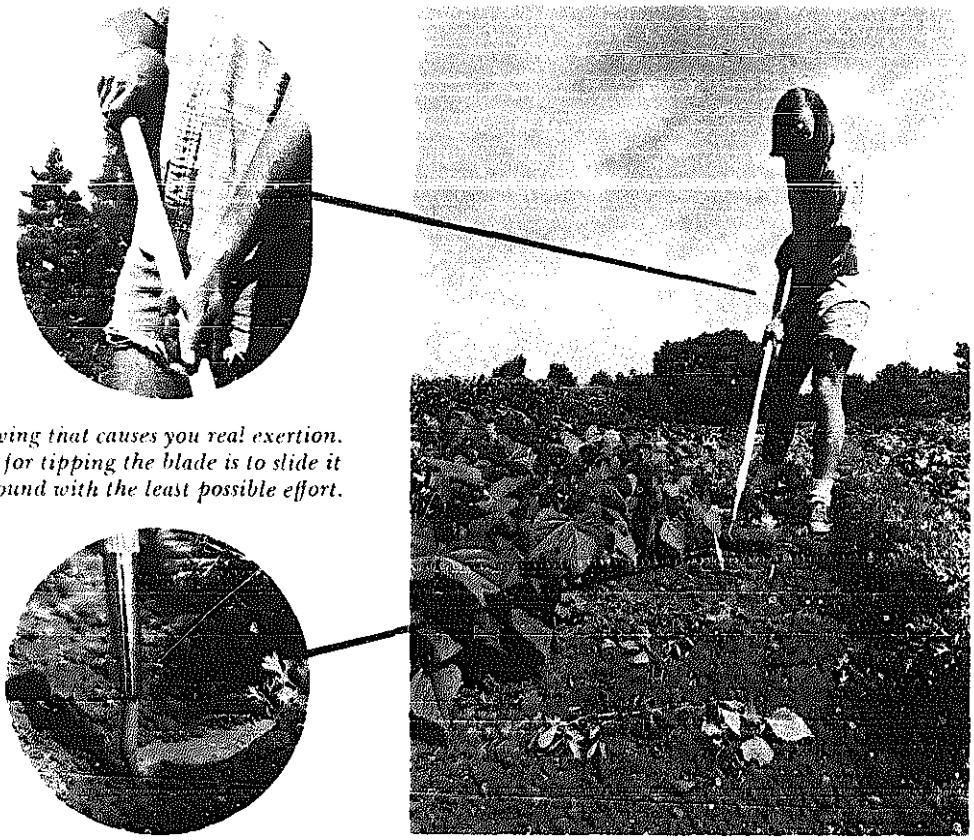
The handle of a good tool is worth its weight in gold. Here we see two Bulldog tools flanking a standard hardware-store tool. Although all three are of D construction, the Bulldog gives you more gripping area, and room to maneuver your hand. The metal support and the rivet construction on the standard spade are subject to damage and weakening, while the split wood construction of the Bulldog is pinned for safety, stability, and long life. In addition, the natural split wood handle is more pleasing to the eye.

As for methodology, your aim is to destroy the root system. To do this without getting tired in the first half hour, tip your hoe blade to one side. Now chop an arc from one side of the row to the other, taking short, easy strokes and bringing your blade into contact with the ground as close to flat as you can. When each stroke stops, your blade edge should be about two inches under the surface and should have traveled about six inches through the soil. Now, on the way back to the right, move your arc forward about three inches and repeat. Instead of hitting the weeds head on and actually chopping them, you'll be slicing them off with the sharp hoe blade.



1) The pronged weeding hoe; 2) the Warren cultivating hoe; 3) the garden hoe; 4), 5), and 6) all-purpose garden hoes.
True Temper

The trick is to never take a swing that causes you real exertion. If you flail at that one big thistle, you'll run out of energy long before you run out of weeds.



Never take a swing that causes you real exertion. The reason for tipping the blade is to slide it into the ground with the least possible effort.

THE WARREN HOE

by Paul Koepke

Ever since primitive agricultural man forsook the pointed stick for more sophisticated cultivating tools, the hoe, in its various forms, has been found to be indispensable. No gardener's arsenal is thought to be complete without a standard garden hoe, and many have found the weeding, grubbing, and scuffle types useful on occasion.

Another type, the Warren hoe, has been unjustifiably neglected—in many areas it is almost completely unknown despite its practicality and remarkable versatility.

The Warren hoe was originally developed to make furrows for planting potatoes. Its unique design makes it admirably suited for this purpose. The blade is shaped like an arrowhead with a rounded tip and barbs, and in the standard model, it tapers throughout its six-inch length by curvilinear reduction from four and one-half inches at its base to the slightly rounded tip. In addition, the blade curves inward slightly toward the handle. It is longitudinally convex on the near surface and correspondingly concave on the obverse, with the thickness of the metal diminishing from one-eighth inch near the base to one-sixteenth inch at the tip. Mounted on the handle with the usual gooseneck found on the common garden hoe, it is canted inward at about 20 degrees from the perpendicular for greater efficiency.

This remarkable implement has capabilities far beyond the purpose for which it was designed. It can penetrate both loose and partially compacted soil with ease. Often, only one solid whack is sufficient to bury its head well below the roots of an offending weed, and a gentle tug will expose the interloper in its

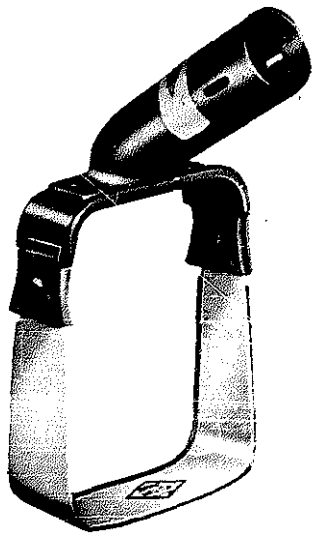
entirety. The pointed tip suits it admirably for pecking at the soil in confined spaces, while the absence of any cutting edge makes it possible for one to work the surface near the base of plants without danger of damaging any tender roots.

The Warren hoe is also an excellent furrowing tool to the depth of six inches, and when laid on its side with the point slightly depressed into the soil, it can be drawn parallel to a row of plants. It is also a well-balanced implement which lends itself readily to one-handed manipulation, leaving the other hand free to pick up and discard undesirable matter.

This excellent gardening aid has only two limitations: it is not an efficient breaker of stubborn clods, and it cannot cut. For those purposes the common garden hoe is without peer. But for quick, clean cultivation, easy furrowing, and delicate weeding, the Warren hoe is a champion.

SCUFFLE HOES

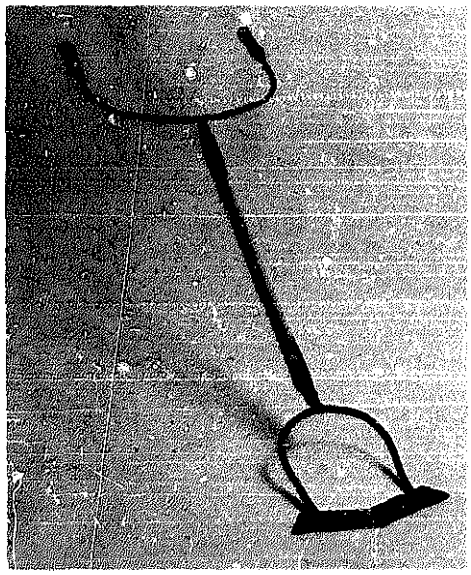
When seed farmer Rob Johnston thinks of cultivating, he thinks of a hoe for his vegetables—the scuffle or action hoe in particular. "It hoes when pushed as well as when pulled. The thin blade rocks back and forth slightly on the handle mounting so that the cutting angle is proper whether pushed or drawn. It is fast and effective on the annual weeds and works well on grass if the blade is kept filed. We were skeptical when we first noticed this hoe on the market, but we received one as a gift and liked it so well that we went out and bought another."



The Scuffle Hoe
Polar-Werke

THE LINCOLNSHIRE LONGHORN HOE

This tool was invented and developed in Lincolnshire, England, 300 to 400 years ago. "The pilgrim fathers may have used a hoe like this around Boston, U.K., before they sailed to America," suggests a manufacturer, David Tonge. Still used in Lincolnshire for larger gardens, small fields, odd corners, and headlands, it was originally used as a tool to fill the gap between the ordinary hand hoe and horse-drawn cultivators.



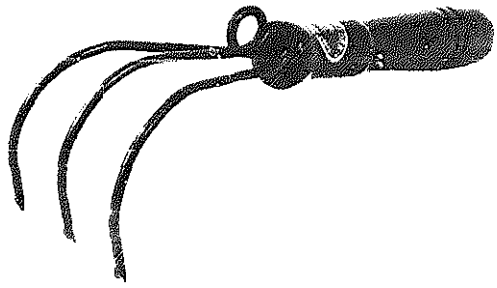
The Lincolnshire Longhorn Hoe

To use it, you stand in between the handles and push the hoe backward and forward while walking forward. The art of using it is to keep the blade one-half-inch deep in the soil while keeping the blade level. "A big selling point," says Tonge, "is that it enables one person to cover a lot of ground in little time. A fit and able man in a seven-hour day should be able to hoe four to five acres in 20-inch rows."

Oatsheaf Enterprises
Chapel Farm, Martin Dales
Woodhall Spa
Lincolnshire LN10 6XT U.K.

PRONGED WEEDERS

Most gardeners and small farmers have the need for a three-pronged hand weeder once in a while. They are useful in pulling out perennial grass in vegetable rows and in removing weeds between plants. "The best one that we have found is made by Mechanical Applications in Wiscasset, Maine," says Rob Johnston. "They call these tools Magic Weeders and they come in three handle lengths. They feature spring-steel prongs which have a better action in the soil than the stiff prong types."



The Magic Weeder

SPADES

SPADING

To turn the soil over, a spading fork is usually better than a round-pointed shovel, though both are adequate.

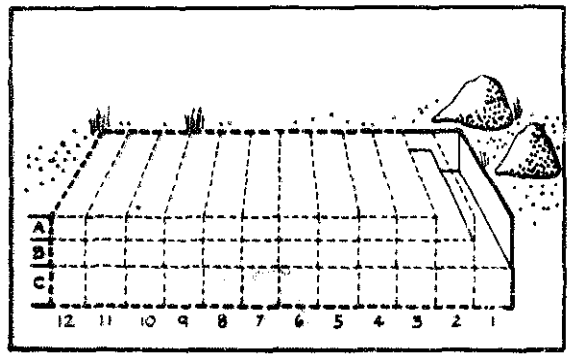
To spade, dig a trench about the depth of the shovel blade or fork tines (the depth to which you can easily plunge a spade). The dirt dug out is put in the wheelbarrow and wheeled to the other end of the plot to be spaded. It will be used to fill in the last trench.



To spade, dig a trench about the depth of the shovel blade, put the dirt in a wheelbarrow, and save it to fill in the trench left after spading.

Next, simply dig another trench next to the first one, turning the dirt a spadeful at a time, upside down into that first trench. Tip the spadeful of dirt on its side rather than completely upside down. That leaves the plant residues and other organic matter that were on the soil surface at varying depths of the spaded dirt rather than buried completely at the bottom of the trench. The organic matter will rot faster that way.

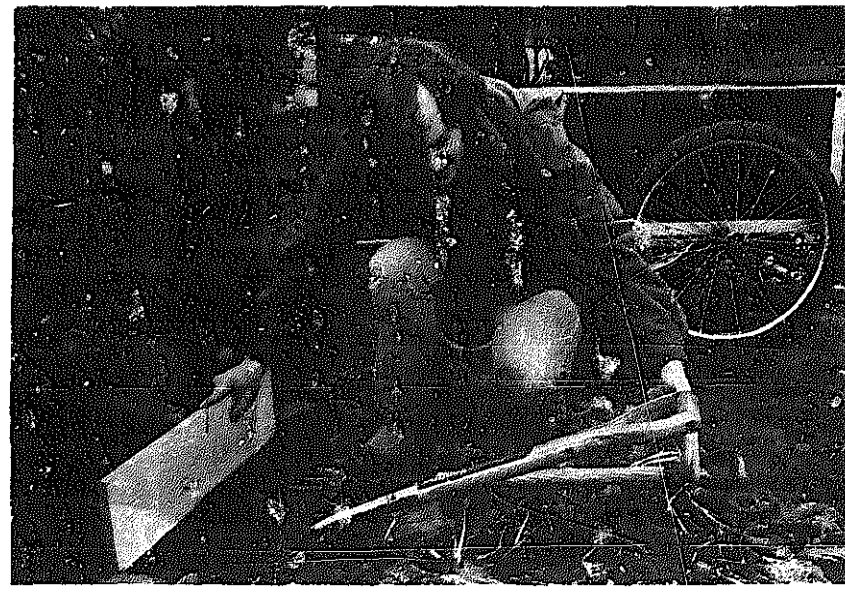
Proceed across the garden in the same fashion, spading, turning, spading, turning. Don't be in a hurry and take too big a bite. Take care to keep the spading side of the trench straight up and down. In sod, the grass mat on top of the soil will make spading more difficult. When grass is still attached to unspaded sod by the roots, use a round-pointed shovel rather than a spading fork; the shovel will cleave the roots better. At the edges of the sod plot to be spaded, mark a line and then go along the length of that line with the shovel, jamming it down about four inches to slice through the grass roots. Then while spading, the shovelful along the edge will lift out easily. This will also clearly mark the edge of the area to be spaded.



Triple spading is the ideal: the garden soil is carefully spaded and mixed. The top layer (A) is removed from blocks 1 and 2 and saved for eventual use in blocks 11 and 12. Soil is next removed from block 1B and saved for use in block 12B. Next, 1C is spaded to loosen and turn the soil. 2B is moved to cover it, and 3A is used to top off block 1. The sequence continues until the entire garden has been spaded. The process is laborious, and in practice is seldom done.

When the soil is turned over, give each spadeful a whack to crumble it, or stick the shovel or fork into it and twist. Either maneuver breaks up the clod a little and leaves the surface loose and friable.

If you are spading in the fall or early winter, leave the surface rough after spading. As is true with fall plowing, the rough soil surface will absorb and hold more water through winter and freezes will mellow it better. The soil will also dry out faster in spring. Work the surface as soon



When you're talking about working in the garden, it all comes down to how much strain you put on your back. Here we see a Bulldog spading fork in the foreground and a standard spading fork in the rear. Notice how when the fronts of the tines are even, and the pivot points the same, the Bulldog gives you a full eight inches less bend to do the same work. Multiply that eight inches across a 25-by-25-foot garden, and you've saved yourself some mighty sore muscles.

as you can after spading, in spring or early summer, so that finer soil on the surface will hold soil moisture. Don't work the soil deeply, though, as that will only drag sod or other plant residues already spaded under back on top of the ground.

DIGGERS

The U-Bar Digger

A 50-by-50-foot plot of land can be dug to a depth of 18 inches in two hours with Eric Brunet's U-Bar Digger. Two handles support a bracket with very long digging tines. To use it, the prongs are forced into the soil with the foot, handles at arm's length. The handles are then pulled back toward the body and rocked back and forth to crumble the soil sitting on the tines. Leverage does all the work. This same action can be used to raise potatoes, turnips, and other root vegetables. No source is available at this time.



Eric Brunet and his U-Bar Digger.

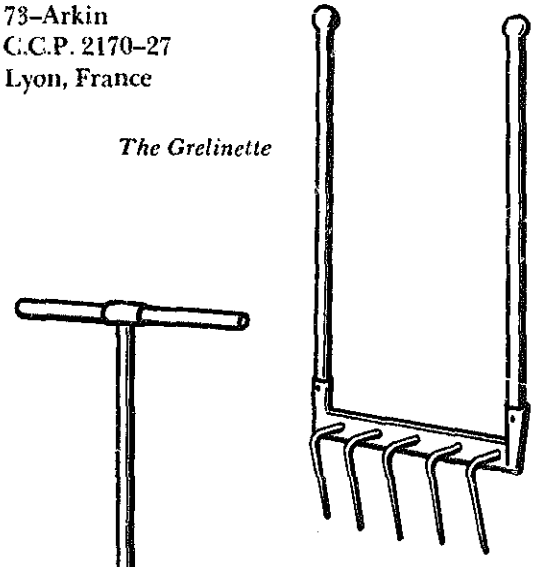
The Grelinette

Similar to the U-Bar Digger is the Grelinette from France. The manufacturer claims it will work ten times faster than ordinary labor and is not as exhausting. "We say that it is a biological tool because it integrally respects the bacterial life in the soil and soil structure, both of which benefit cultivation. This is a new gardening tool offering a rational technique of manual labor to mellow the soil without turning it over."

Besides loosening the soil, the Grelinette can be used for digging potatoes and root crops, fertilizing tree roots without damaging them, planting leeks, and aerating the soil for proper water and nutrient penetration.

A. Grelin
73–Arkin
C.C.P. 2170–27
Lyon, France

The Grelinette



The Fourche Beche en T

227

Fourche Beche en T

This is another French fork for working the soil without turning it over.

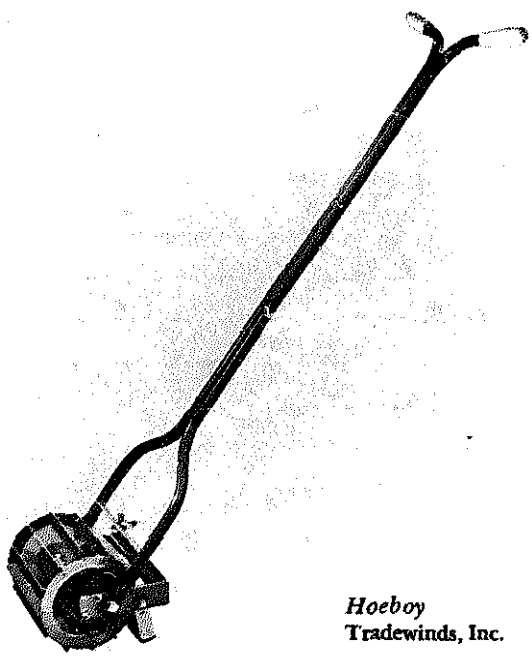
Association Culturelle
1 rue des Basses Boulangeres
77850 Heriey, France

ROTARY CULTIVATORS

Hoeboy Rotary Cultivator

Hoeboy is an unusual Danish-built rotary cultivator with 12 blades to penetrate and break up surface soil and lift it in layers to form an air-filled mulch conducive to bacterial action. A knife at the rear cuts through weeds and soil below the surface, causing roots to wither and die. The cutting depth is adjustable and is set so as not to injure lateral roots of garden plants. The compact 8½-inch width makes it easy to work narrow rows and close planting. Knife bars and cutter bar are of spring steel and bearings are of Etronax, requiring little or no lubrication.

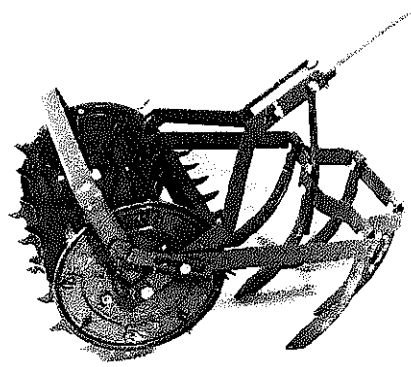
Tradewinds, Inc.
P.O. Box 1191
Tacoma, WA 98401



Hoeboy
Tradewinds, Inc.

Ro-Ho

The eight blades on this unit have 40 hoe points—20 angled right, 20 angled left—to give stirring action to the soil when the wheel rotates.



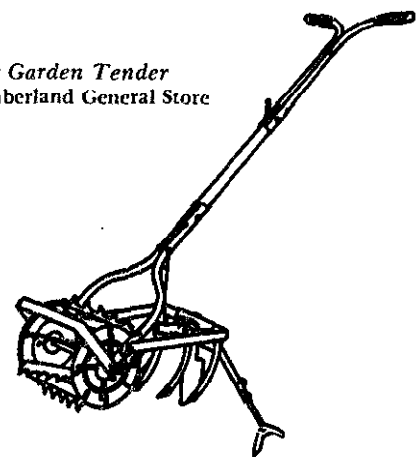
Ro-Ho
Rowe Enterprises, Inc.

Use one or more of the five cultivator shovels to match tillage needs. The scuffle knife cuts a layer to a depth of 1 inch.

Rowe Enterprises, Inc.
Galesburg, IL 61401

Garden Tender

This cultivator is similar to the Rowe Ro-Ho, but has a seed furrow-shovel/row marker attachment.



The Garden Tender
Cumberland General Store

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

Rotary Hoe Soil Pulverizer

Similar to the Rowe Ro-Ho.

Kumaon Nursery
Ramnagar
Nainital (U.P.) India

NORTH AMERICAN SOURCES OF HAND CULTIVATION TOOLS *

	HOES	SCUFFLE HOES	CULTIVA-TORS	SPADES	FORKS	SHOVELS	RAKES
AMES	X	X	X	X	X	X	X
BELKNAP, INC.	X		X	X	X	X	X
W. ATLEE BURPEE CO.			X				
CENTRAL TRACTOR	X		X		X	X	X
COUNTRYSIDE CATALOG	X		X		X		
CUMBERLAND GENERAL STORE	X		X	X	X	X	
FARM & FLEET	X	X	X			X	X
DEAN FOSTER NURSERIES	X			X			X
GLEN-BEL'S COUNTRY STORE	X		X	X	X	X	X
LEHMAN HARDWARE & APPLIANCE, INC.			X				
A. M. LEONARD & SON, INC.	X	X	X	X	X	X	X
BEN MEADOWS CO.	X					X	X
MONTGOMERY WARD	X			X	X	X	X
MOTHER'S GENERAL STORE CATALOG					X		
NASCO AGRICULTURAL SCIENCES	X		X	X	X	X	X
G. E. RUHMANN MFG. CO., INC.						X	
SEARS, ROEBUCK & CO.	X		X	X	X	X	X
SEYMOUR MFG. CO.	X						
STANLEY GARDEN TOOLS—U.S.	X		X	X	X	X	X
TRACTOR SUPPLY CO.	X	X		X	X	X	X
TRUE TEMPER CORP.	X	X	X	X	X	X	X
THE UNION FORK & HOE CO.	X	X	X	X	X	X	X

INTERNATIONAL SOURCES OF HAND CULTIVATION TOOLS

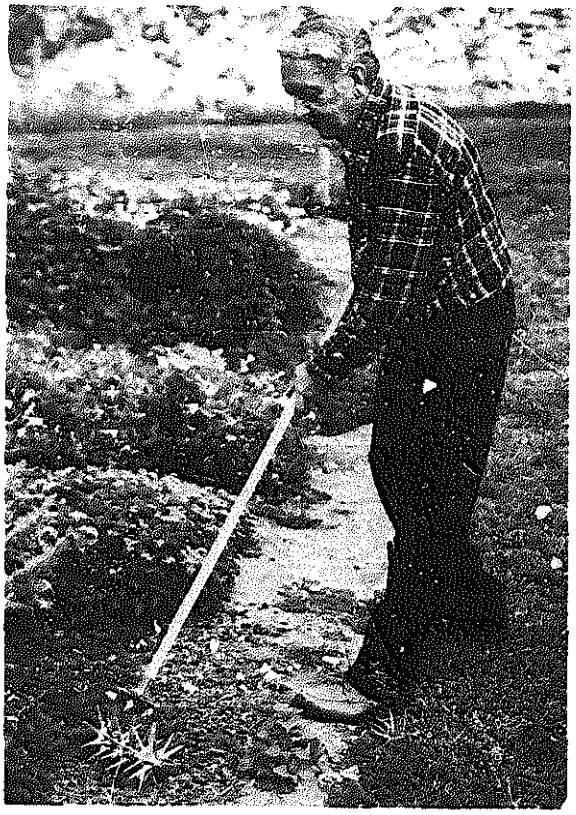
	HOES	SCUFFLE HOES	CULTIVA-TORS	SPADES	FORKS	SHOVELS	RAKES
AFRICAN HOE (PTY.), LTD.	X						
BULLDOG	X			X	X	X	
CEAF S.N.C. F.LLI SILETTI	X		X		X	X	X
THE CHILLINGTON TOOL CO., LTD.	X						

* Address for the companies listed in charts in this book can be found in the Appendixes A and B.

	HOES	SCUFFLE HOES	CULTIVA-TORS	SPADES	FORKS	SHOVELS	RAKES
COOPEXIM-CEPELIA	X		X	X		X	X
COSSUL & CO. PVT., LTD.	X						
ENGLISH TOOLS, LTD.	X			X	X	X	
FERFOR	X		X	X	X	X	X
FERUNION	X						
CG FUNCKE SOHN	X		X		X		X
HERRAGRO	X					X	
HILTON ENTERPRISES CO., LTD.						X	
HINDUSTAN ENGINEERING CO.	X		X			X	X
JENKS & CATELL, LTD.	X		X	X	X	X	
KUMAON AGRI-HORTICULTURE STORES	X			X	X	X	
KUMAON NURSERY	X		X		X		
KUMAR INDUSTRIES	X				X		
LASHER TOOLS (PTY.), LTD.	X			X	X	X	X
MOHINDER & CO. ALLIED INDUSTRIES				X			
NIKKO CO., LTD.	X		X	X	X	X	X
OY RETTIG-STRENGBERG, AB					X	X	
PEUGEOT	X		X		X		X
GEORGE PIKE, LTD.	X			X	X	X	X
POLAR-WERKE	X	X	X	X			X
SHW SCHWABISCHE HUTTENWERKE GMBH	X		X	X	X	X	
SCOVIL HOE CO.	X						
SELF-SUFF. & SMALL-HOLDING SUPPLIES	X			X	X		X
SOCIETE DES FORGES TROPICALES	X			X			
SPEAR & JACKSON TOOLS, LTD.	X		X	X	X	X	
STANLEY GARDEN TOOLS, LTD.	X		X	X	X	X	X
SYNDICAT DE L'OUTILLAGE	X		X	X	X	X	X
THE TATA IRON & STEEL CO., LTD.	X					X	
W. TYZACK SONS & TURNER, LTD.	X		X	X	X	X	
UBUNGO FARM IMPLEMENTS	X			X	X	X	
UNITED REPUBLIC OF TANZANIA			X				
VILHARD & CO.	X		X		X		
WOLF TOOLS FOR GARDEN & LAWN, LTD.	X		X	X	X		

Garden Weasel

Used to scarify the top layer of soil, the Garden Weasel is comprised of three pairs of eight-pronged metal wheels. The wheels are removable, and the unit may be used with one, two, or three sets for cultivating different-sized rows.

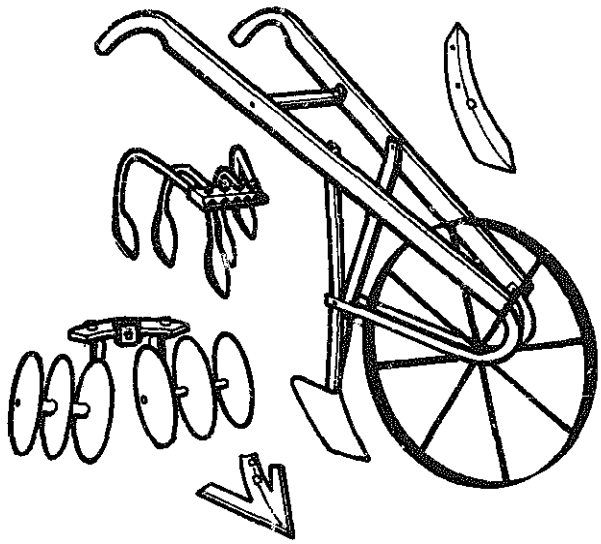


The Garden Weasel at work
Faultless Starch/Bon Ami Co.

Faultless Starch
Bon Ami Co.
Kansas City, MO 64101

THE WHEEL HOE

A real cultivation time-saver for small-sized farming operations is a hand-pushed wheel hoe. Essentially a multipurpose tool taking several attachments, it is useful for operations like weeding, hoeing, hilling, furrowing, cultivating, and even cutting roots. The three most popular attachments for accomplishing these tasks include: (1) the turn shovel or moldboard plow; (2) reversible shovel and (3) five-pronged weeder. Many other variations are available.



The wheel hoe with (top to bottom): shovel, five-pronged weeder, disc cultivator, and sweep.

Rob Johnston finds the six-inch-long blades to be the most useful attachment when caring for his vegetables. They run just below the soil surface as the hoe is pushed along and weed very close to small plants without throwing soil on them.

Supporting the attachments is a metal, tubular, or wooden frame with either a small or large wheel. The larger wheel makes pushing a bit easier, but a small wheel offers better control over the cultivating attachments. Most units have a straight handle frame bolted to the wheel. However, the overshot frame is advertised as being easier to push.

The wheel hoe is best put to work in the early stages of weed growth. It can be used for a continuous operation if one person pulls by rope while another pushes, but is most often pushed about two feet, pulled back, and pushed another two feet.

Double-wheel hoes are hard to find in North America since Planet Junior stopped making theirs, but they are well distributed throughout the developing nations. These units have a high arch connecting the two sides, permitting the operator to straddle a row of quite tall plants to cultivate both sides at once. A few models of

single-wheel hoes will do all that the two-wheel models do except straddle tall (over eight or ten inches) plants, especially the erect plants like corn, reports Rob Johnston. "To straddle a row with the single-wheel hoe, the wheel is mounted to one side of the frame, instead of on center, and cultivating tools till each side."

When using wheel hoes for cultivation, rows may be sown as close as ten inches apart, showing a clear advantage over layouts which depend on a tiller for cultivation, necessitating wasteful, wide row spacing.

Care and maintenance are two important factors in determining the longevity and performance of any tool. It is important to remember the blade of a hand tool is its most important part. When purchasing a hand tool for cultivation, make sure that the blade is made of carbon or high-carbon steel so that it remains sharp and does not wear out quickly. It is important to keep the cutting edge of the blade sharp; otherwise too much power will be required to work it, and both the quality and total work done in a day will be reduced. The blade should be cleaned after use and a bit of grease applied to the cutting edge before storing.

Tom Ulich has spent many long hours using a wheel hoe on his small farm. He writes, "If I had to choose a single cultivating tool in addition to a hoe, it would surely be the Planet Junior No. 17 Wheel Hoe. These units are easily serviced and extremely durable. They may be used to cultivate any crop in row widths from eight inches on up. They work well on just about any type of good garden soil, and their ease, speed, and accuracy of operation are remarkable. A person in reasonably good physical condition can cultivate faster and more accurately with one of these hoes than with any rotary tiller I have ever seen. (I have cultivated an acre of crops in less than four hours with one of these hoes.) Furthermore, wheel hoes are about the most environmentally sound means of cultivating, besides being an excellent form of exercise. Everyone here on the farm finds using a wheel hoe extremely satisfying and pleasurable—even the children like it."



The Planet Junior No. 17 Wheel Hoe: The low wheel is more difficult to push but offers more control over the cultivating attachment.

NORTH AMERICAN SOURCES OF HAND WHEEL HOES

Planet Junior

It is available in either low- or high-wheel models. There is a full line of attachments including seeders and fertilizer drills. The high-wheel model has direct connection of handle to wheel. Low-wheel hoes place attachments right at the end of the handle for best control of the implement. The manufacturer can still replace parts for antique equipment.

Planet Junior Division
Piper Industries
P.O. Box 1188, Freeport Center
Clearfield, VT 84106

Cumberland

This model is constructed of 16-gauge tubular steel with painted, baked enamel.

Equipped with a 20-inch, sealed ball bearing wheel with rubber tire, handle grip, and 8-inch sweep. Designed to accept all standard implements for garden use. They also carry Planet Junior models.

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

Empire Garden Plows

A full line of attachments can be used on this high-wheel hoe with overshot frame and wooden handles. There's a straight frame model on the 18-inch, low-wheel model with a metal extension from wheel to attachment. The manufacturer can still replace parts for antique equipment.

Empire Plow Co.
Cleveland, OH 44127

Speedy Gopher

A 16-spoke, wide-rimmed, high-wheel hoe with a rear wheel allowing the operator to adjust the cultivating or furrow depth.

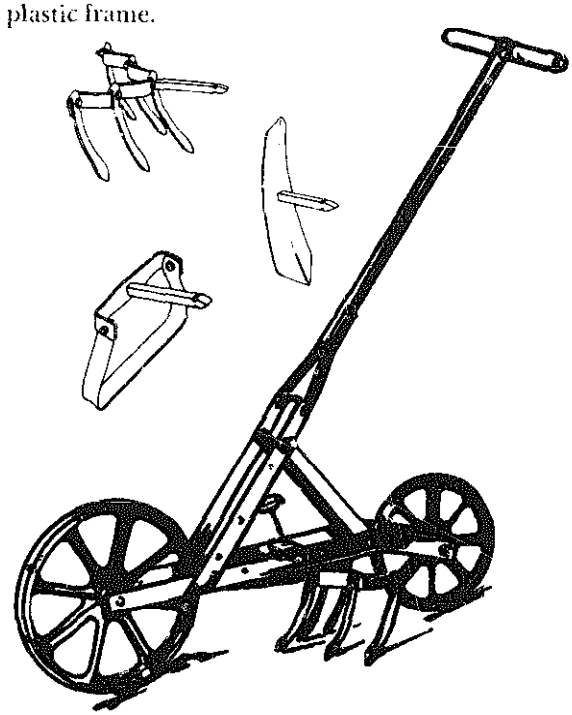


The Speedy Gopher Winona Attrition Mills

Winona Attrition Mills
1009 W. Fifth St.
Winona, MN 55987

Earthway Cult-A-Eze

Two wheels are provided for stability and easier operation of this unit. A 10- or 12-inch front wheel is followed by either the five-tine cultivator, slicing hoe, or furrow plow which in turn is followed by a small 5-inch wheel. The unit maintains adjustable depth settings from ⅛ to 3 inches deep. Attachments slide and lock into place on the corrosion-resistant, heavy plastic frame.



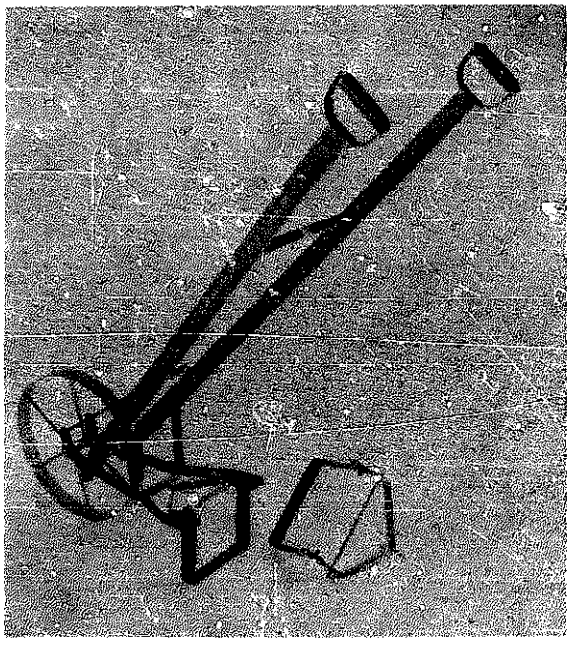
The Earthway Cult-A-Eze with pronged weeder, blade, and shovel attachments.
Esmay Products, Inc.

Esmay Products, Inc.
P.O. Box 547, Maple St.
Bristol, IN 46507

ALMACO Hand Wheel Hoe

Two models are available with either 8- or 9-inch cutting blades. Both have a 14-inch guide wheel, hardwood handles, and a cutting depth adjustment.

Allan Machine Co.
P.O. Box 112
Ames, IA 50010



ALMACO Hand Wheel Hoe Allan Machine Co.

Hand Wheel Hoe

A full line of attachments is available for this high-wheel hand hoe.

Plow Mfg. Co.
Department MG
Bridgewater, VA 22812

Hand Wheel Hoe

You can get a full line of attachments for this high-wheel hand hoe.

Lambert Corp.
519 Hunter Ave.
Dayton, OH 45404

Distributors of Wheel Hoes

Distributors for these manufacturers of hand wheel hoes include the following:

Belknap, Inc.
P.O. Box 28
Louisville, KY 40201

Countryside Catalog
Rt. 1, Box 239
Waterloo, WI 53594

Farnam Equipment Co.
P.O. Box 12068
Omaha, NB 68112

Glen-Bel's Country Store
Rt. 5, Box 390
Crossville, TN 38555

Lehman Hardware & Appliance, Inc.
Box 41
Kidron, OH 44636

A. M. Leonard & Son, Inc.
P.O. Box 816
Piqua, OH 45356

Montgomery Ward
1000 S. Monroe St.
Baltimore, MD 21232

Mother's General Store
Box 506
Flat Rock, NC 28731

Nasco Agricultural Sciences
901 Janesville Ave.
Fort Atkinson, WI 53538

Sears, Roebuck & Co.
Farm and Ranch Catalog

INTERNATIONAL SOURCES OF HAND PUSH CULTIVATORS

Aspec APS-51 Hand Wheel Hoe

Hoe, plow, and cultivator attachments are available for this hoe. Weight: 7.5 kilograms.

American Spring & Pressing Works Pvt., Ltd.
P.O. Box 7602
Malad, Bombay 400 064, India

Single-Wheel Hand Hoe

Attachments for plowing, cultivating, harrowing, hoeing, opening and closing furrows, and hilling-up plants are available for this model. The frame is of pressed steel, and slots are designed for easy adjustment of attachments. Weight: 10 kilograms.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

High Hoe

The High Hoe is strongly constructed, yet light and easy to use. The blades can be placed in a number of different positions for either center or side hoeing, and can be adjusted by simply undoing two wing nuts. The handles can be adjusted to three different heights for ease of use.

Highlight Engineering Co., Ltd.
Dunnington
Yorkshire, Y01 5LP, U.K.



The Jalo Hand-Pushed Cultivator with furrower, hiller (moldboard), cultivator tines, hoes, lawn aerator, and rake.
Jalo Engineering, Ltd.

Jalo Hand-Pushed Cultivator

This model can be used with one wheel (for cultivating between crop rows) or two wheels (for cultivating both sides of a single crop row). Attachments include plow, rake, ridging body, cultivators, and rotary pulverizer. It has a metal frame.

Jalo Engineering, Ltd.
Wimborne Industrial Estate
Mill Lane, Wimborne, Dorset, U.K.

Single-Wheel Hoe

Hoe, cultivator, plow, and rake attachments are supplied for this implement.

Kumaon Nursery
Ramnagar, Nainital
U.P., India

Thilot Hand Weeding Machine

This cultivator can be used with either one or two wheels. It is fitted with wooden handles and can be supplied with left- or right-handed plow bodies, cultivator tines, hoe blades, and a ridging plow—a low-wheel hoe.

Phyco b. v.
Postbox 79
Leusden-G, Netherlands

Hand Wheel Hoe

Attachments for furrowing, plowing, cultivating, and hilling are available for this low-wheel hoe.

A. J. Troster Landmaschinenfabrik
6308 Butzbach, Oberhess
Postfach 240, West Germany

Three-Tine Adjustable Hand Hoe

Union Tractor Workshop
8-B, Phase II
Mayapuri Industrial Area
New Delhi 110 027, India

Other Manufacturers of Wheel Hoes

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Danishmand & Co.
Karkhana Bazar
Lyallpur, Pakistan

International Mfg. Co. (Regd.)
Hospital Rd., Jagraon
Ludhiana, Punjab, India

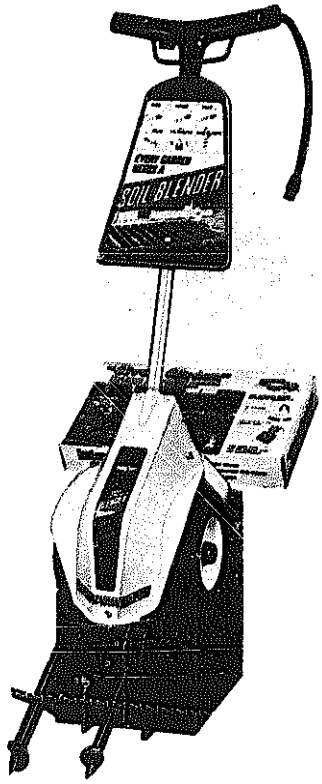
Mohinder & Co. Allied Industries
Kurali, Dist. Ropar
Punjab, India

Self-Sufficiency & Small-Holding Supplies
The Old Palace, Priory Rd.
Wells, Somerset BA5 1SY, England

POWER CULTIVATORS

Soil Blender

This is an electric garden tool designed to dig 12 inches deep, mix soil, fertilizer, or compost from 1 to 9 inches deep, till 3 to 9 inches deep and 12 inches wide, hill 6 inches high on 18-inch centers, and cultivate 1 to 3 inches deep and 12 inches wide. A variable speed switch provides blade rotation from 0 to 125 rpm. It has a ¾ h.p. electric motor, direct gear, and chain drive. Weight: 33 pounds.

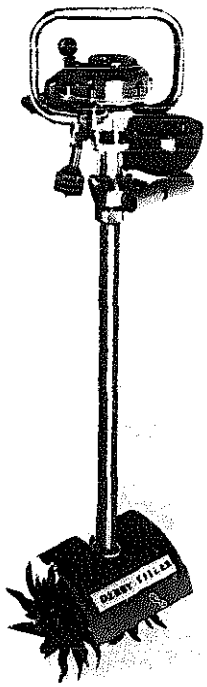


Soil Blender
Garden Maid Division, Detroit Tool and Engineering

Detroit Tool and Engineering
The Garden Maid Div.
P.O. Box 232
Lebanon, MO 65536

Derby Tiller Power Hoe

Designed for heavier cultivating work than you would want to approach by hand, the Derby Power Tiller consists of a single support tube with 32 guarded tine teeth at one end and a 1 h.p. gasoline motor at the other. Weighing 17 pounds, it gives a finely granulated deep till in one pass, working in 12-inch wide rows at depths up to 8 inches.



Derby Tiller Power Hoe Derby Tiller Co.

The Derby Tiller Co.
P.O. Box 21
Rumson, NJ 07760

A. M. Leonard & Son, Inc.
P.O. Box 816
Piqua, OH 45356

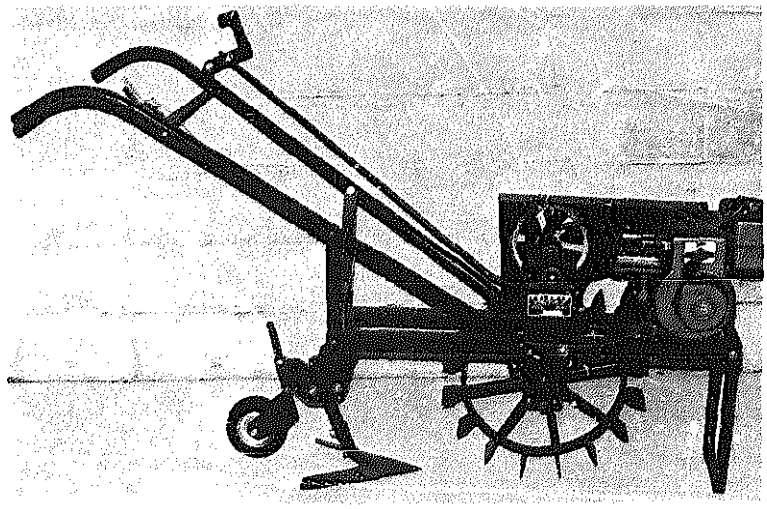
Bluebird

A gasoline engine powers this model's oscillating cultivator tines for an action which leaves an even layer of loosened soil without throwing soil on plants or damaging larger plant roots. Features include depth control and compact, fold-down handles.

Precision Valley Mfg. Co.
Box 9004
Springfield, VT 05156

Coleman Garden Plow

The Coleman garden plow is a one-row plow that facilitates plowing close to plants without damaging them. The cleated wheel has enough traction to enable slow and deep plowing. Attachments include a 12-inch sweep for cultivating, a two-prong fork for covering seed



The Coleman Garden Plow
Coleman Garden Plow Mfg. Co.

when planting, and extra attachments for breaking the ground, planting, and cultivating.

The engine is mounted in front for balance and easy handling, and adds weight to the cleated pulling wheel for better traction. The plow foot and depth wheel are adjustable.

Coleman Garden Plow Mfg. Co.
Rt. 8, Box 106
Dothan, AL 36301

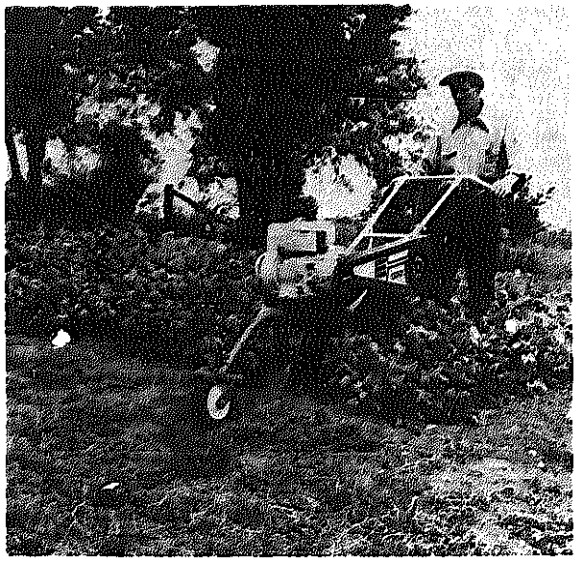
The Carolina Plow

This is a one-drive-wheel unit powered by a 4½ or 5 h.p. engine mounted on a heavy steel and tubular frame. The tillage tool is located in front of the drive wheel and below the engine. Attachments include sweeps, turning plows, corn shovels, hillers, and cultivators. A smaller model is also available.

C. M. Products Sales Co.
Div. of Oneida Metal Products
P.O. Box 895
Rhinelander, WI 54501

EDKO Power Wheel

The compact EDKO workhorse incorporates a maintenance-free design on a balanced frame. The 5 h.p. engine with 6-to-1 gear reduction powers a chain-drive system to a 23-inch diameter lug tread tire. Liquid ballast is added for traction. Turn, corn shovels, and sweep plow are standard equipment for furrowing, hilling, and cultivating. The tool bar and handlebar are adjustable. Other attachments are available.



EDKO Power Wheel
EDKO Mfg., Inc.

EDKO Mfg., Inc.
2725 Second Ave.
Des Moines, IA 50313

PADDY WEEDERS

These implements uproot weeds and bury them in the soil. They work best in soils covered with a shallow depth of water and are readily available throughout Asia in different sizes to accommodate different row widths. One-row units are usually pushed by hand, but larger two- and three-row units are available with a power unit.

SOURCES OF PADDY WEEDERS



IRRI Push-Type Weeder
International Rice Research Institute

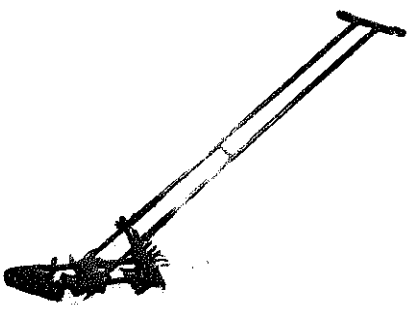
IRRI Push-Type Hand Weeder

This is a simple weeder equipped with two spiked wheels rotating in a supporting frame, the front of which forms a skid. The two rotors and skid are made from light sheet metal and are easily dismantled for cleaning and repair. The handle is made of wood. The leading skid serves as a depth control for the wheels. Build-it plans are available from IRRI for this simply constructed implement.

International Rice Research Institute
P.O. Box 933
Manila, Philippines

Paddy Weeder

This is a lightweight, all-steel weeder. It is best used on fields where 25 to 50 millimeters (1 to 2 inches) of water is standing. The rotary blades remove weeds and aerate the soil, thus encouraging crop growth. Weight: 5 kilograms.



Cossul Paddy Weeder Cossul & Co.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

Akshat Rotary Paddy Weeder

Cultivation by this implement between the rows of plants kills weeds and aerates the roots of the crop. It has a front skid and a tubular steel handle which is adjustable for different operators and soil conditions. It is available in two models, the AK-53, 150 millimeters wide and weighing 3.3 kilograms, and the AK-55, 90 millimeters wide and weighing 3.0 kilograms.

American Spring & Pressing Works Pvt., Ltd.
P.O. Box 7602
Malad, Bombay 400 064, India

Hand-Operated Paddy Field Weeder

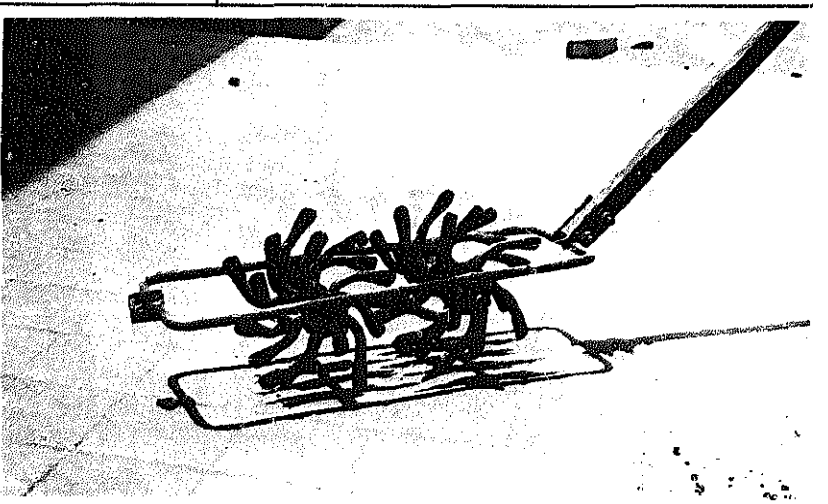
The CeCoCo weeder is U-shaped with a float and two claw wheels, and it has a wooden handle which can be adjusted to suit the height of the operator.

It has a width of 150 millimeters to suit row spacing of 210 to 230 millimeters. Weight: 5 kilograms.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Rotary Weeder Plan Number 16

Labeled photographs illustrate how a rotary weeder for row-planted rice can be locally built.

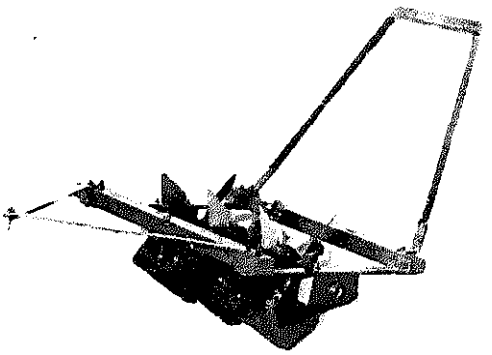


ITDG Paddy Weeder

Intermediate Technology Publications, Ltd.*
9 King St.
London WC2E 8HN, England

Bullock-Driven Wetland Puddler

Covering 3 to 4 acres per day, the Puddler is designed for quick and efficient preparation of paddy fields after first plowing. It reduces the number of plowings necessary and breaks up clods and lumps. The three angular, cast-iron hubs with four blades on each hub churn up the soil and leave fine particles on the soil surface.



Cossul Bullock-Driven Wetland Puddler
Cossul & Co.

* All Intermediate Technology publications can be ordered from International Scholarly Book Services, Inc., Box 555, Forest Grove, OR 97116.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

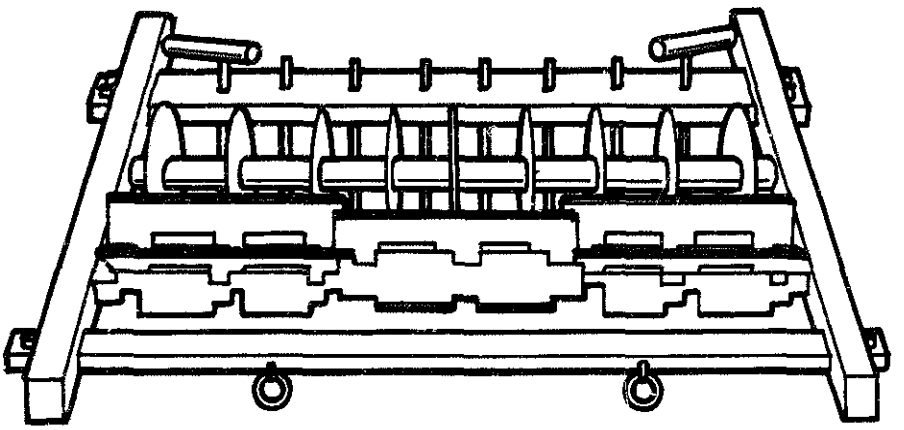
Animal-Drawn, High-Clearance Rotary Hoe Plans

The rotary hoe is designed for weeding crops grown on paddy ridges at 75 to 90 centimeters spacing. It cultivates both sides of one ridge at a time and does not require straight and parallel ridges for efficient weeding. Cultivation is done by two gangs of four spider wheels, each having ten backward-curved tines. The rotary hoe can be used for weeding closer to the crop than sweep cultivators without causing apparent crop damage. Performance is good if weeding is carried out while the weeds are small, and the implement is designed to ride over stumps or other obstructions in improperly cleared land.

Intermediate Technology Publications, Ltd.
9 King St.
London WC2E 8HN, England

Japanese Puddler Plans

Illustrations for a multiaction paddy field puddling tool with Japanese design reveal a wooden frame. The 8-inch steel rotating discs, cutting knives, and rotating chopper blades are suitably designed for local construction.

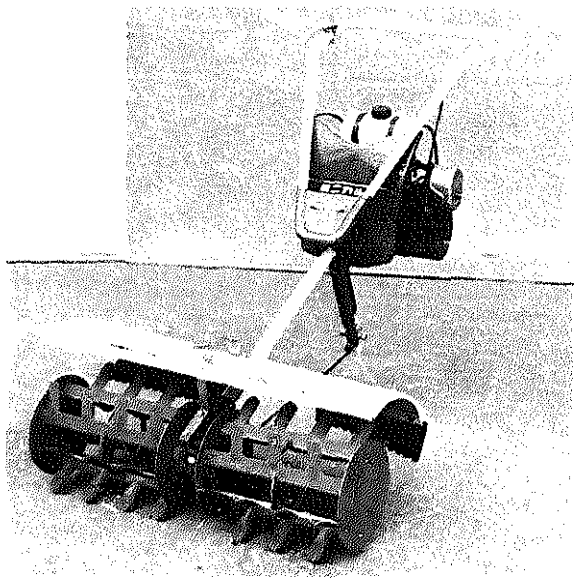


Animal-Drawn Japanese Puddler

Intermediate Technology Publications, Ltd.
9 King St.
London WC2E 8HN, England

IRRI Power Weeder

This three-row power weeder was designed by the International Rice Research Institute for use in lowland areas of developing countries. Many local manufacturers have adopted their design. Build-it plans are available from IRRI.



A Japanese manufacturer's verison of the IRRI power weeder adapted to light upland tillage requirements.
International Rice Research Institute

International Rice Research Institute
P.O. Box 933
Manila, Philippines

Mametora Rice Paddy Cultivators: Shan Shan MRT-3 and MRT-D

The MRT-3 is a three-row tiller with safety guards. The MRT-D is a cultivator which combines tilling and trenching work. It will till three rows at one time or trench one row in a "V" shape so that roots are not damaged. Both are lightweight, have adjustable handles, and are easy to maneuver. Tilling supplies oxygen and expels nitrogen gas which has generated from straw scattered in the paddies after harvest. The nitrogen must be expelled to prevent root rot and other damage.

A two-cycle, air-cooled, 2.2 h.p. gasoline engine is mounted on the handles where it balances the construction and places weight on the cultivating attachments. Model MRT-3 has a capacity for covering about an acre per hour while the MRT-D will cover the same area in 30 to 40 minutes.

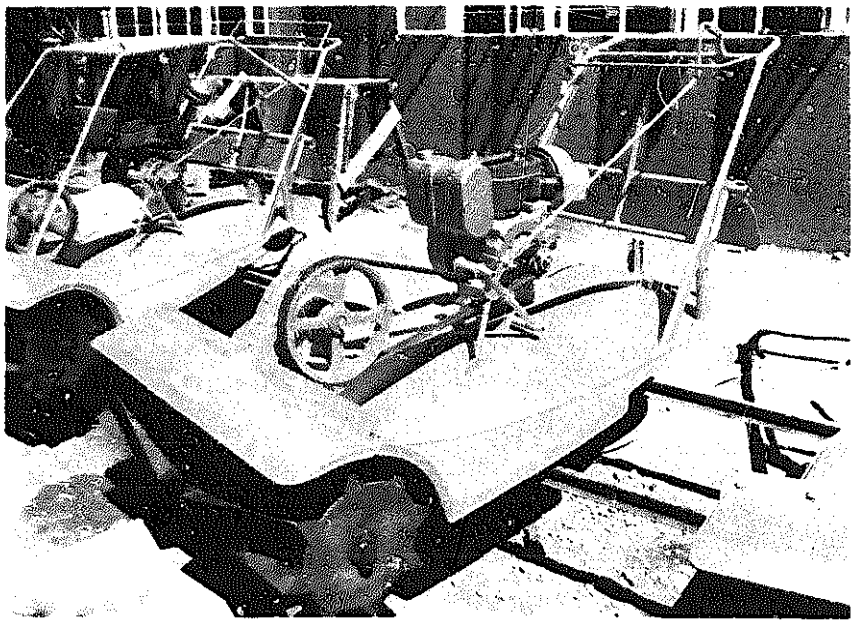


IRRI Power Weeder
International Rice Research Institute

Mametora Agricultural Machinery Co., Ltd.
9-37 Nishi 2-chome
Okegawa, Saitama, Japan

Turtle Power Tiller

The Turtle power tiller was invented by a Filipino for the Filipino and designed especially for wet and waterlogged rice fields and fish ponds. It can mow, plow, rototill, and level. Power is supplied by either a 10 to 16 h.p. gasoline engine or a 6 h.p. diesel engine. Fuel consumption is 12 and 6 liters per 8-hour day, respectively. It has front-end drive and is 44 inches wide followed by a skid design body. Length: 55 inches. Capacity: 1.5 hectares in eight hours. (One hectare equals approximately 2.47 acres.)



Turtle Power Tiller
S-V Marketing

S-V Marketing
65 Commission Civil St.
Jaro, Iloilo, Philippines

FRONT-END TILLERS

A TILLER'S WORK IS NEVER DONE

by Gene Logsdon

After the leaves have been spread on the garden—along with the plant residues, horse manure, rock powders, and other soil amendments—it's time to get out the rotary tiller. The tiller chops them into the top eight inches or so of the soil where plant roots do their foraging and the humus and nutrients do the most good. The tiller is thus the organic gardener's basic humus-building tool, but it is also a lot more.

If you're approaching a weed- and shrub-infested or sodded piece of ground for the first time, intending to turn it into a garden, sample a small area with the tiller to make sure the machine has the muscle to do the job.

Neither front-end tiller nor rear-mounted model will do a good job of primary tillage on heavy sod or dense weed growth in soil that has not been cultivated in recent years. Don't expect the impossible from any tiller, even the heavier rear-mounted ones which generally chop up plant residues better than lighter front-end types.

A front-end tiller will bounce off hard, sod-bound earth just about the way it will bounce off rocks. A rear-mounted tiller won't exactly bounce, but it will lunge forward, jerking you with it. If you have no other way to work such soil, the secret, with either kind of tiller, is to go lightly over the surface repeatedly, skimming off only an inch or less with each pass—slow, hard work.

It's better to plow—or have someone plow—such soil in the fall, then work it in nicely the following spring with your tiller. Or, cover the area with deep mulch in the spring, and when that has rotted away together with the sod under it, then rotary till.



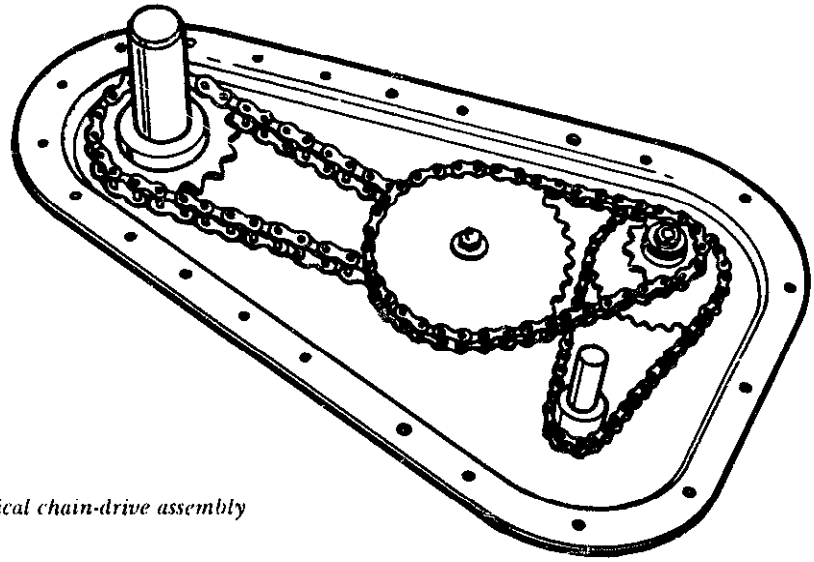
The rotary tiller earns its keep on the homestead by preparing garden beds in the spring, cultivating crops all summer long, and enriching the soil in fall with compost and cover crops.

You may be able to chop up and incorporate heavy plant growth like corn with a pass or two of your tiller, but really heavy, dense growth should be mowed with a rotary mower first. That makes the job much easier, because inevitably that dense green stuff will tangle and entwine in the tiller tines, and you'll have to get down and cut it out. A small amount of clogging can be cleared by reversing the direction of the tines while raising them just a wee bit above digging depth.

The kind of tines your tiller is equipped with—and how sharp they are—has more to do with clogging than whether the tiller is front- or rear-mounted. There are at least four kinds of tines: three-bladed chisel tines, four-bladed slicer tines, four-bladed slasher tines, and four-bladed bolo tines. Chisel tines are the cheapest, okay for cultivating, but they tangle the easiest if you try to incorporate plant residues with them. I wouldn't recommend chisel tines for organic gardeners. Slicer tines will dig from six to nine inches deep but will also tangle and clog where there is a lot of plant residue. Slasher tines are designed to cut and chop residue better with less clogging. They are longer than slicers (on six horsepower models) and will dig up to 11 inches deep. Bolo tines can be used on the bigger, six to eight horsepower tillers; these tines are heavier and wider

and move more dirt per revolution, so you can move along at a faster speed. They are also less affected by clogging.

As you shop for a tiller, another choice presented is between gear-driven and chain-driven models. Gear-driven models are usually, if not always, combinations of belt and gear drives. A belt transfers the power from the motor shaft to the worm gear shaft, which then transfers power to the tine axle. Mathematically, the chain drive is more efficient since the transfer of power is more direct. Which is better? It's a toss-up in my opinion, as long as you are comparing models in the same price range. Chain drive will probably wear out quicker but is easier and cheaper to repair.



Typical chain-drive assembly

So let's pretend you have bought your tiller, and it's the first day of the gardening season. Preferably, your garden has been cultivated the previous year or was plowed the previous fall if virgin ground. You pick up a handful of dirt, squeeze it into a ball, press your thumb against it. If the ball crumbles apart easily, the earth is ready.

Don't try to see how deep the tiller will dig on the first pass—especially if you have plowed under sod. You don't want to drag those sod chunks back to the surface. Let your tiller dig only a couple of inches on the first pass. If you have the time, let the ground dry a bit before making a second pass. The second time, the tines will bite into the ground more easily and work the ground into a fine, crumbly texture. Dig at least six inches deep, and try for eight to ten, if possible. Set the brake bar at the rear of front-end tillers at a depth that will allow you to push it in and pull it out of the ground with ease, according to the depth you want to dig. Don't fight your machine; let the brake bar and the tines do the work. You push down, the brake bar holds the tiller back for digging; you let up, the tines propel the tiller forward. With gentle pressure between up and down, you allow the machine to inch forward slowly while it digs.

A rear-mounted tiller is even easier to handle. You set it for depth and speed; then all you have to do while the machine digs is guide it.

Work the ground the second time at right angles to the first pass if possible. You may need to go over the ground a third time to get a fine seedbed, but usually twice is enough, if your soil is in good condition.

After planting, your tiller becomes a weed cultivator. It can be used as a harrow for that first important cultivation of deep-sown seed (two to three inches) before the seed comes up, but when weeds are already germinating. This type of cultivation is tricky. You want to go over the ground

very lightly, gently disturbing the soil surface without digging in to disturb the germinating seed. Skim very fast over the row, and you will kill many small weeds you can't even see yet. But don't try this technique on shallow-sown seeds.

As soon as your plants are above ground, you can start cultivating with the tiller between the rows. Unlike shovel cultivators, the tiller tines will not throw dirt onto the new plants and bury them, if you do not dig too deep. For cultivating, deep digging is not necessary anyway and can be harmful. If weeds are growing faster than your plants, however, and you must dig a little deeper to control them, you can buy special plant shields that fit on either end of the front-end tiller axle and prevent the dirt from falling on your plants (Sears has them). The hood on a rear-mounted tiller performs the same job.

When your plants are taller, you want the tiller to roll some dirt into the plant row, if possible, to bury the tiny weeds emerging there. That can save you hand weeding. So, without shields, you let the tiller dig a little deeper than you might otherwise, though not so deep as to cut into your plants' roots.

Front-end tillers can be modified quickly to cultivate between rows as narrow as six to eight inches or as wide as 26 to 30 inches. The narrowest width is achieved by taking the outer tines off completely and turning the inner ones around so the blades point inwards. Two intermediate widths can be attained by either leaving the two outside tines off completely with the two inside tines in regular position, or by replacing the outer tines with the blades pointed inwards and the two inner tines in regular position. Clip bolts, which hold the tines on the axle, are easy to remove, and the tines are easy to slip off the axle.

Remember to allow a few inches more for row width than the width of your various tine positions. If, for example, you intend to cultivate a swatch 26 inches wide, make your rows at least 30 inches wide—if not 32—to accommodate that 26-inch width. Why? You don't want the tines cutting too close to your plant roots; and when the plants grow taller, the whirling tine blades have a way of reaching out and grabbing them if you get too close.

If a tiller could talk, it would probably sigh, "A tiller's work is never done." Attachments turn it into a digger of garden irrigation ditches, or furrows, or rows for planting seeds. There's a hiller attachment for front-end tillers, too. I even know of someone who turned his tiller into a sidewalk edger by replacing one of the outside tines with an old plow coulter welded to a piece of pipe!

Tillers are handy for renovating berry patches and ripping out runners that are getting out of control. The tool is handy for pruning raspberry suckers growing out beyond the sides of the row where they don't belong. For cultivating or incorporating mulch under fruit trees in small orchards, the tiller is better than more cumbersome tractor machinery, and it is handier for cultivating under trellis wires between grapevines. The tiller is superb for running over asparagus beds in fall or spring to kill weeds and volunteer asparagus seedlings growing above the deep-set roots. Just don't dig more than three inches deep.

Some chicken farmers, who raise their flocks on litter, utilize tillers to mix and stir the old litter in place on the coop floor to speed the composting process. Tillers are handy to mix compost in large worm beds, too, before seeding with worms. In any raised bed, or confined greenhouse bed, the tiller is about the only power tool that can be utilized. Lighter models that can be lifted in and out of the beds without back sprains are preferable for this kind of work.

Care of the tilling parts is simple. Keep the oil bath around the worm gear at the specified level. On chain-driven models, the chain and bearings should be lubricated when and if it is necessary.

The motor, the heart and soul of your tiller, requires much more attention. Most walking, self-propelled tillers, if not all, are powered by air-cooled, one-cylinder, four-stroke engines—which, to mechanical amateurs like myself, simply means that they take oil in the crankcase and gasoline in the engine, and you do not mix the two as you do with two-stroke engines. According to Allen Brown, agricultural engineer at Purdue, a properly maintained four-stroke engine ought to give good service for at least five to eight years and probably longer. If an engine fails sooner than that, it usually means improper care. "A main cause of early failure is not keeping enough oil in the crankcase," he says. "Another is failure to change oil as often as recommended, and a third is using the wrong kind of oil."

Brown recommends changing oil every 25 operating hours—or sooner if very dirty conditions prevail. Use SAE 30 weight oil in summer and SAE 5w-20 or 5w-30 in winter (if you use your tiller in cold weather, which is not likely). If you can't get 30w, 10-30 will do. Do not use nondetergent oils with an API classification of MS, SC, SD, or SE.

Clean the air cleaner whenever you change oil, or more frequently. Neglect allows dirt to get into the cylinder and cause bearing failure. There are oiled filters, dry filters, and oil bath filters: follow the manufacturer's directions for your particular model.

Keep the whole motor clean. Don't let dirt and debris clog the cooling fin, as an overheated engine wears out faster.

An old motor can often be given new life by cleaning out the carbon buildup in the exhaust ports. Take off the muffler and you'll find the holes (usually three).

An important rule in keeping an engine running longer is never to run it at top speed for extended periods of time. There's rarely an occasion that justifies roaring around the garden at full throttle. You'll get finished at half-speed just as soon—and with better fuel efficiency. And your neighbors will love you, too.

Perhaps it is surprising to find coverage of the familiar front-mounted Rototiller in a book specializing in the hard-to-find. But surprisingly enough, there is a hard-to-find aspect to tillers which makes them an appropriate consideration for the farm tool collection, and that is versatility. Of course, the simplest models are strictly for tilling; they have front-mounted tines to break and cultivate the soil. But realizing the multipurpose potential of the little tiller as a power source, some manufacturers have produced attachments for a variety of operations. In North America, attachments are designed mainly for cultivation, while European models have a number of working tools for jobs like pumping and spraying.

TILLER ATTACHMENTS

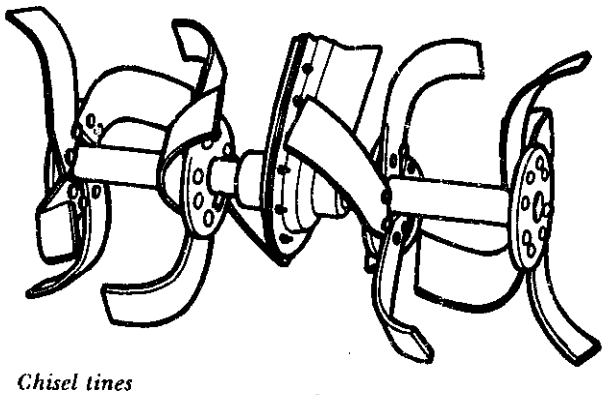
Rather than discuss the many different tillers as power sources, we have decided to concentrate on attachments and their functions. A chart following the tool descriptions explains which manufacturer carries which tool. Manufacturers' addresses are listed in the index.

Tines

Tines are the blades of the Rototiller which do the actual soil tilling. Many manufacturers have coined their own names to represent their tines as unique. But actually, there are just a few basic designs that most follow.

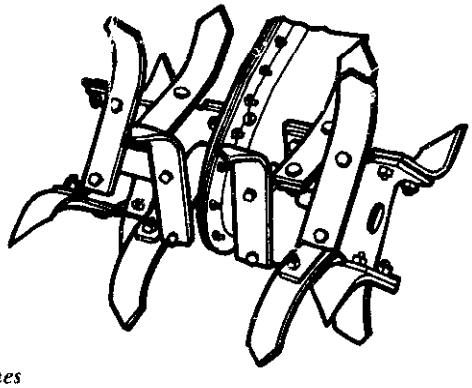
Slicer—A medium-duty, short, knifelike tine.

Slasher—Similar to but more rugged and longer than the slicer, good for breaking up sod on virgin ground; cuts and chops plant residue with little clogging.



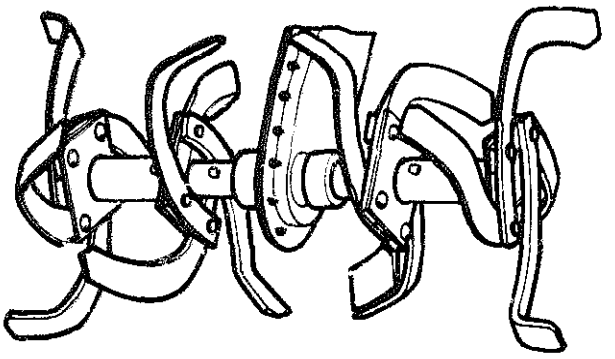
Chisel tines

Chisel—Sometimes referred to as pick tines, good for rocky ground, clay, and hardpan. Clogs easily, not good for grasses or weeds.



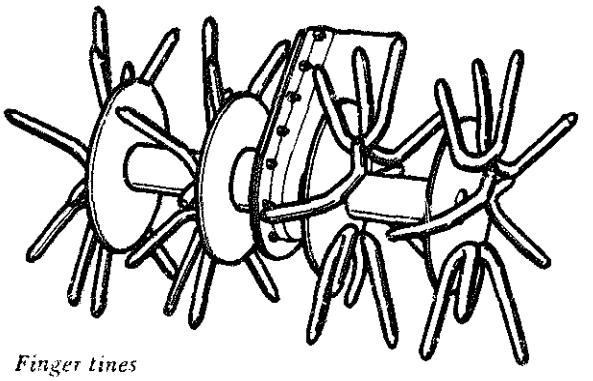
Slasher tines

Bolo—Heavy, wide tines good for normal cultivation and mulching without clogging with plant residue.



Bolo tines

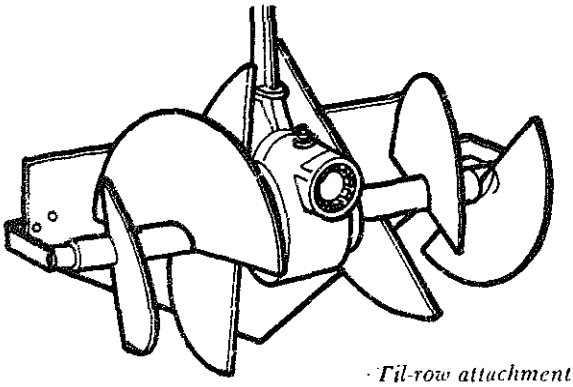
Finger—Provides positive traction, good for cultivating and seedbed preparation.



Finger tines

Til-Row

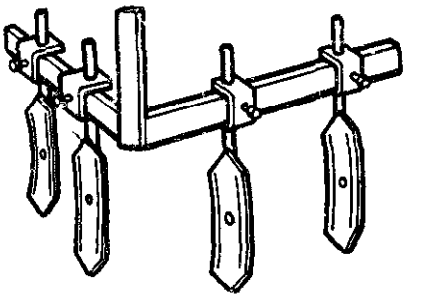
In place of tines, the til-row attachment builds rows, provides a prepared seedbed, and with the back plate removed, it converts to a cultivator. It can also be used to dig irrigation or drainage ditches.



Til-row attachment

Cultivators

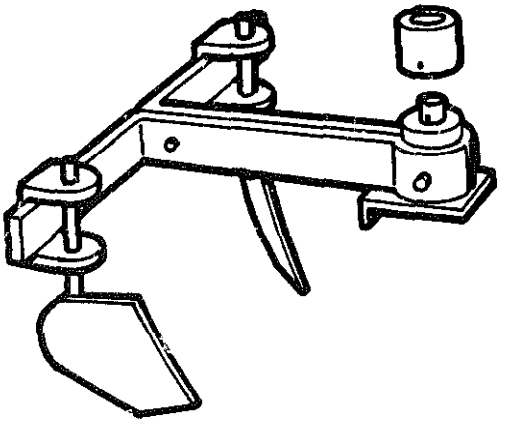
Cultivators appear with many different names and variations on a similar theme. Shovels, spikes, or spring-tooth tines are either fixed permanently on a frame or bolted to a toolbar, the latter being adjustable. Called either cultivators or harrows, they perform the function of removing weeds or preparing seedbeds by being pulled through the soil. Five-tine weeders, plow sweeps, and various hoe designs are available.



Cultivating shovels mounted on a toolbar

Plows

Small-power units have a limited amount of traction and power which limits their plowing capabilities as well. They do best at making furrows or hilling already-tilled soil. A furrow opener will dig a shallow trench for straight line or root crop planting which would otherwise

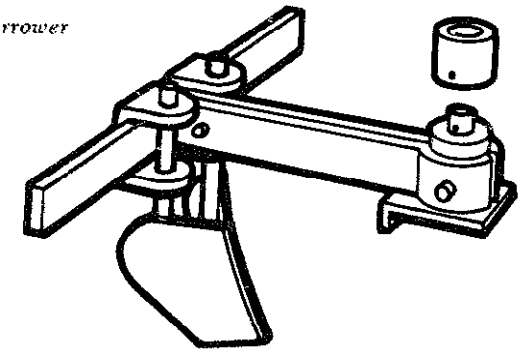


Hiller

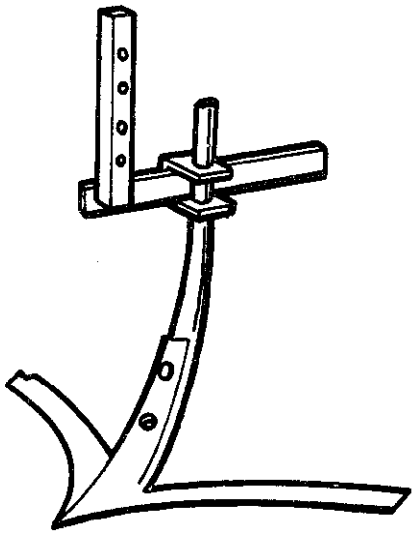
require digging holes. Hillers then fill in the furrow or hill-up around other plants.

It is worth mentioning that a hilling plow is actually one-half of a furrower. Some companies offer a furrower in two parts which, working together, furrow and hill separately. Furrowers are sometimes referred to as moldboard plows and hillers as turning plows.

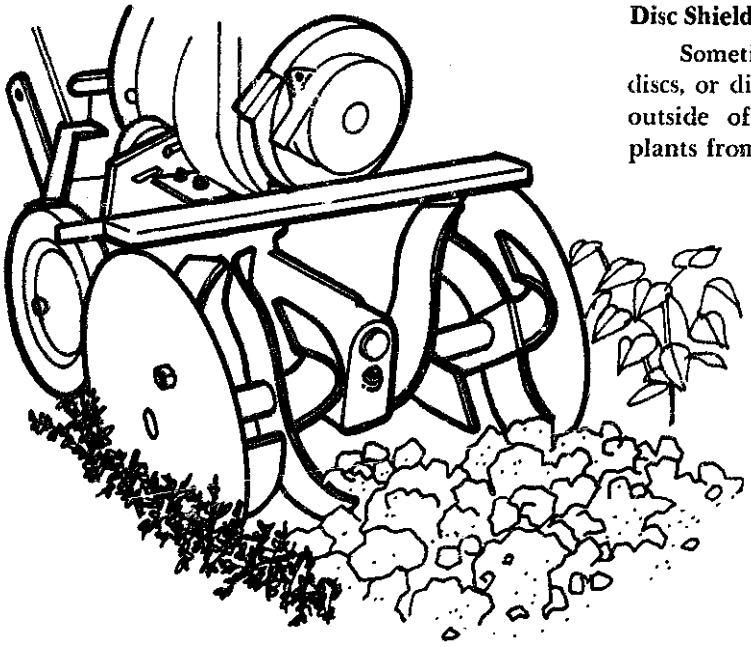
Furrower



A sweep plow is another kind of cultivating tool which makes a wide pass to cut weeds beneath the surface of the soil at a desired depth.



Sweep



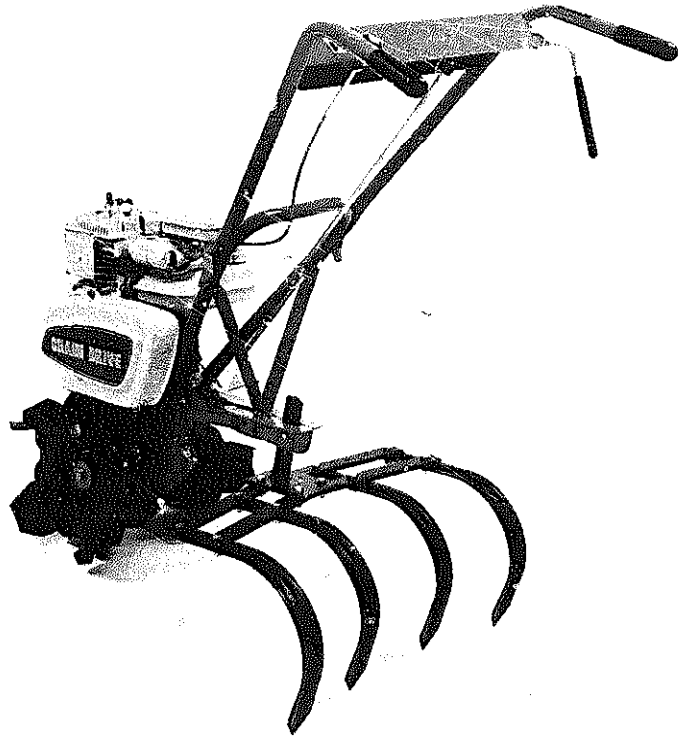
Disc Shields

Sometimes called cultivating shields, side discs, or disc shields, these devices bolt onto the outside of rototilling tines to protect young plants from having soil spill over on them.

Disc shields keep soil from falling onto young, fragile plants.

Wheels and Tires

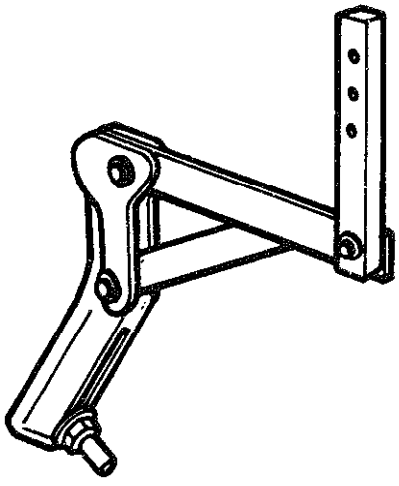
Most small tillers are sold with small semi-pneumatic or rubber tires which offer little traction. These are fine for rototilling since traction is provided by the action of the tines themselves. However, for plowing and cultivating, the extra traction provided by larger pneumatic or rubber tires or steel wheels is desirable. Tire chains, transport wheels, and wheel weights are also available.



Gilson Model 51104 compact chain-drive tiller with drive wheel and cultivator.
Gilson Brothers Co.

Small depth gauge wheels are provided with some attachments to offer support and depth guidance.

Plow Foot and Toolbar



Plow foot

Some attachments mount directly onto the tiller frame, others to a toolbar or plow foot which is mounted to the frame. They offer a means of adjusting tool positioning for both width and depth of work. Bulldozing and snow-plowing blades appear with many of these models. Snowblowers are uncommon.

Mowers and Lawn Attachments

Mowers are uncommon to small, North American tiller models because the power take-off is usually limited to use with tiller tines. European models, however, are built with versatility in mind and have attachments for rotary, sickle bar, or spindle reel mowing. The listing of European models is meager here because most tillers are built to perform so many utility functions that they have been included in the two-wheel tractor section.

Some Unusual Tiller Attachments and Their Sources

See the Appendix for addresses.

Front-end carrier—Wolseley
Mulcher—Agria
Sprayer—Agria, Hako
Pump—Staub
Roller—Staub
Vine Guard—Auto Hoe
Shredder-Grinder—Roto-Hoe

THE GROUNDHOG: TILLER FROM A KIT

by Raymond Trull

After 14 years of hard work in gardening, my faithful tiller announced its imminent retirement with a chorus of grindings and rumblings and clouds of blue smoke.

What would replace it? In helping others in my gardening family, I'd used many well-known tillers, including Burns, Merry, Snapper, and Gilson. While most had good and not-so-good features, all were durable, hard-working machines. A tour of local dealers and an examination of gardening magazines made me itch to try every super clean, brightly painted new model on the stones, sticks, weeds, and dirty soil of my garden. There was nothing pretty about those tillers' prices—they had doubled in 14 years. To buy without carefully studying both quality and price was a foolish luxury I couldn't afford.

With attachments, many tillers convert to minitractors that plow, cultivate, rake, make planting ridges, harrow, and even move materials with a scrape blade. Could tillers be practical and efficient minitractors for gardens and small area crops? I wanted to know!

The Groundhog, by Heald of Benton Harbor, Michigan, is unique—it's sold as a kit. At $199.95 for a five horsepower, chain-driven model, it's at least $40 less than comparable preassembled models.



Fresh from the factory, the Groundhog is ready for assembly.
Raymond Trull

Groundhog's components are made by companies I recognized—engines by Briggs and Stratton and Tecumseh, chain drives by Parmi, and ground-working tools (a good variety) by Brinly-Hardy. More important, by assembling it, I should understand its internal workings and be able to repair it later. The goal—greater self-sufficiency!

Basic assembly included putting the transmission, frame, and tines together, mounting the engine, and attaching control cables and levers—a nine-hour job for this nonexpert fumblefingers. No tasks

were strenuous or very complicated, but some required careful, patient work. A few wrenches, a screwdriver, and Heald's large drawings and careful directions kept the job moving.

With unexpected pride—it started and worked perfectly—I took the Groundhog to the garden for its first trial and my first surprise. At an engine speed just above idle, it cut six inches deep in garden soil undisturbed for six months. To make its task a bit tougher, I added extension tines for a 36-inch-wide cut. Although an inch of leaves and old stalks covered part of the area, the Groundhog easily maintained its tilling depth and forward speed.

A much tougher test came soon. When dozens of volunteer asparagus popped up among the berries and shrubbery, I wanted to add them to our skimpy parent bed. But before preparing the deep, fertile soil needed by asparagus, a thick sod of common Bermuda grass had to be removed. In the South Carolina Piedmont, Bermuda sod is a devil's brew of intertwined, tough surface runners and a thick underground mat of fibrous roots, usually yielding only to hours of toil with a mattock.

With its extension tines in place, the tiller bounced slightly each time its tines struck. But the Groundhog churned forward slowly, leaving a seven-inch-deep layer of soil and vanquished Bermuda sod in its wake. Three hours' labor was over in twenty minutes!

The Groundhog is an actor with many roles: replace the tines with deep-cleated wheels and it's a minitractor that works. Add a drawbar and make furrows with one plow or raised ridges with two plows in the furrower-hiller set. Replace them with the cultivator-scarifier set's four plows, and removing weeds and making dust mulches is safer for garden plants. Most of the weight of a well-



Optional equipment—here a front-mounted scraper blade and two kinds of rear plows—adapts the tiller for many chores.
Raymond Trull

balanced tiller is concentrated over its tines to make it dig easily and quickly. That's fine, unless you need to protect plant roots. With the Groundhog's culivator plows mounted at the rear drag bar and partially supported by the operator, plow depth is easily controlled.

Add a bit of imagination, and the Groundhog helps with many chores. Leaving two of the four cultivators mounted, I use it to rake together runners from our all-too-vigorous Japanese honeysuckle. (These make good mulch or a condiment for the compost pile when chopped with a lawn mower.) With the two plows still in place, the front-mounted scraper blade can be added for a gentle, mini-earth-moving machine. To flatten the ridge of an old crop terrace, I loosen soil with the cultivator plows and push it into position with the scrape blade. In addition, it smooths soil after potatoes are dug, distributes leaves and compost for tilling in, and spreads gravel. There are other applications and much more optional equipment.

Any problems with the Groundhog? One, due to personal preference. Rototilling with rear wheels in place—many users remove them—lifts the handlebars too high, even with the Groundhog's fine height adjustment. The solution? One extra hole in the wheel attachment rod brings handlebars down to just the right height.

In the minitractor disguise, the Groundhog runs out of traction and starts spinning long before its engine stalls. A better bite—with dual wheels or wider tires—would help in soft soil.

Overall, the Groundhog is a powerful, useful machine comparable to preassembled models. Its price, performance, quick and easy adjustments, and good design clearly recommend it.

I do have one strong opinion. Many gardeners underestimate a tiller's working ability. Except for turning under a heavy sod or green manure crop, a five horsepower, chain-driven Rototiller is not likely to be stumped when used correctly. Can a tiller with attachments provide most, if not all, soil-working power needed for a large garden and small area crops? Yes!

Heald, Inc.
Box 148
Benton Harbor, MI 49022

NORTH AMERICAN SOURCES OF TILLERS

FRONT-END TILLERS AND ATTACHMENTS	TINES—	EXTENSION SET	CHISEL	SLASHER	SLICER	FINGER	BOLO	FURROWER	HILLER	TIL-ROW	CULTIVATORS	OPT. WHEELS	SIDE SHIELDS	PLOWS	BARS & BLADES	MOWERS
AGWAY								X	X		X	X	X	X	X	
ALLIS-CHALMERS *																
AMERIND-MACKISSIC, INC.								X								
ARIENS		X	X					X		X	X	X	X			
ATLAS		X						X								
AUTO HOE								X	X		X		X			
BLACK & DECKER													X			
JOHN DEERE		X						X								
DERBY *																
EDKO				X		X		X			X	X		X	X	
FMC-BOLENS		X		X			X	X	X	X	X	X		X		
FORD *																
GARDEN MAID *																
GILSON		X	X			X	X	X	X	X	X	X		X	X	
HAHN								X								
HEALD								X	X		X	X			X	

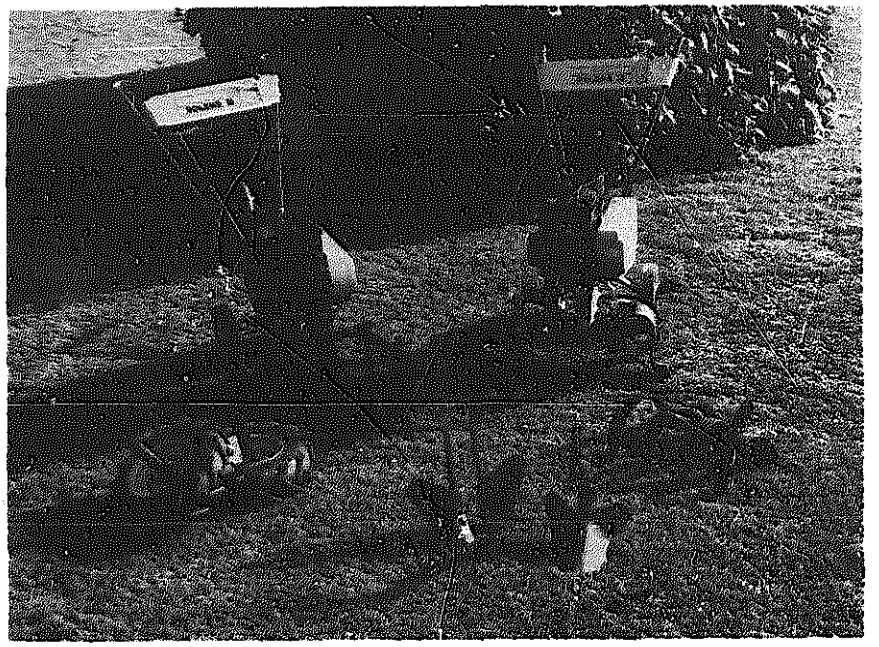
* Tillers only

FRONT-END TILLERS AND ATTACHMENTS	TINES–	EXTENSION SET	CHISEL	SLASHER	SLICER	FINGER	BOLO	FURROWER	HILLER	TIL-ROW	CULTIVATORS	OPT. WHEELS	SIDE SHIELDS	PLOWS	BARS & BLADES	MOWERS
INTNL. HARVESTER		X														
MAGNA				X	X			X	X						X	
McDONOUGH (SNAPPER)							X	X			X	X			X	
MERRY			X	X		X	X	X			X	X		X	X	
MTD								X	X		X	X	X	X	X	
ROPER								X	X	X			X			
ROTO-HOE								X	X							
SEARS, ROEBUCK & CO.								X	X	X			X		X	
SENSATION							X			X						
SIMPLICITY		X						X								
TORO *																
MONTGOMERY WARD		X						X	X	X	X	X		X	X	

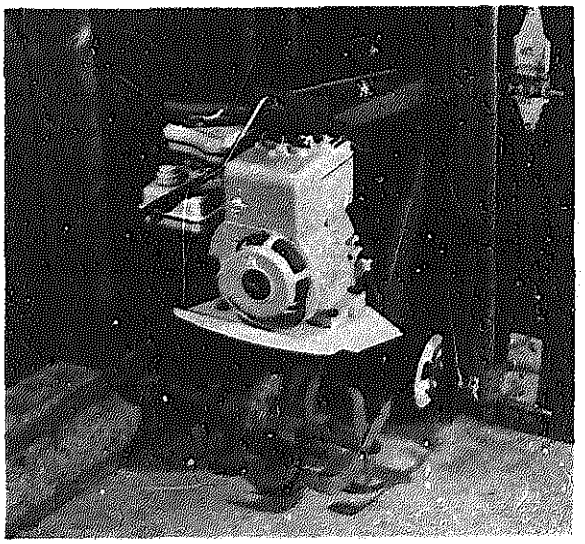
INTERNATIONAL SOURCES OF TILLERS

FRONT-END TILLERS AND ATTACHMENTS	TINES–	EXTENSION SET	CHISEL	SLASHER	SLICER	FINGER	BOLO	FURROWER	HILLER	TIL-ROW	CULTIVATORS	OPT. WHEELS	SIDE SHIELDS	PLOWS	BARS & BLADES	MOWERS
AGRIA-WERKE		X										X	X	X		X
HAKO-WERKE		X							X					X		X
ISEKI *																
MERCHANDISED GARDENING *																
SCHANZLIN											X			X	X	X
SOLO KLEINMOTOREN																
STAUB											X			X		X
WOLF TOOLS *																
WOLSELEY		X	X	X		X		X				X	X	X	X	X

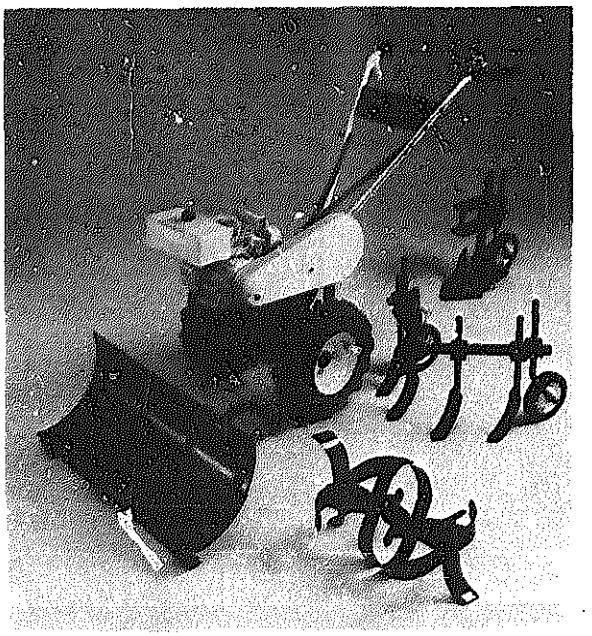
* Tillers only



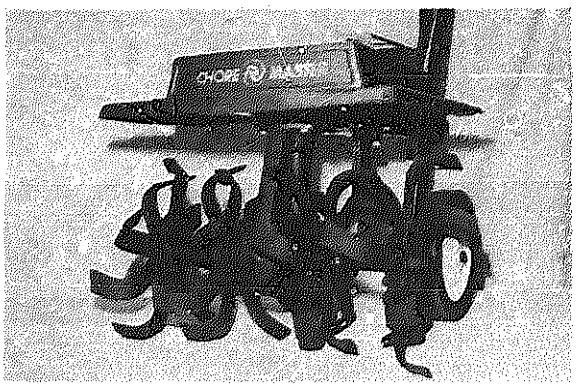
FMC-Bolens power unit and tiller with options: pneumatic tires, harrow, hiller and furrower, cultivator.
FMC-Bolens



The Gilson Compact Tiller requires a minimum of storage room. The same two wing nuts used to fold the handles are also used to adjust the height to suit the gardener.
Gilson Brothers Co.



Snapper tiller with (counterclockwise) pneumatic tires, scraper blade, slasher tines, cultivator/harrow, and furrower.
McDonough Power Equipment



The Magna Chore Master with bolo tines
Magna Corp.

REAR-MOUNTED TILLERS

The rotary tiller is an excellent organic cultivating tool. It can take the place of plow, disc, field cultivator, and offset disc—and can be used as a weed cultivator too. The rotary tiller compacts the soil least of all implements. With the tilling blades mounted in the rear and the engine extending to the front, the result is a well-balanced machine which is easy to maneuver and which has efficient tilling capabilities. Rear-mounted tillers also have an excellent compost-shredding action, which is desirable when incorporating organic material into the soil. (Two-wheel tractors, discussed in chapter four, usually have rototilling attachments.)

But beyond tilling, it is quite common for a tiller to convert to a sickle bar mower or snowblower, or to have provisions for pulling a plow, trailer, or cultivator. Some tillers provide a power take-off (PTO) feature for powering a variety of attachments like pumps and sprayers, or even binders and reapers. These are discussed further in chapter four. Handlebars are usually adjustable to either side so the operator can walk beside the tiller rather than in a freshly tilled row.

NORTH AMERICAN SOURCES OF REAR-MOUNTED TILLERS

Troy-Bilt

The Troy-Bilt is a popular garden tiller, with several choices of model and horsepower. Attachments are available. Two forward and two reverse speeds are provided by the chainless, power train transmission with worm gear. Depth of tilling can be regulated to seven different levels while the machine is in motion, and the handles are adjustable as well. Attachments include a furrower (for trench composting) and a snowplow.

Garden Way Mfg. Co., Inc.
102nd St. & Ninth Ave.
Troy, NY 12180



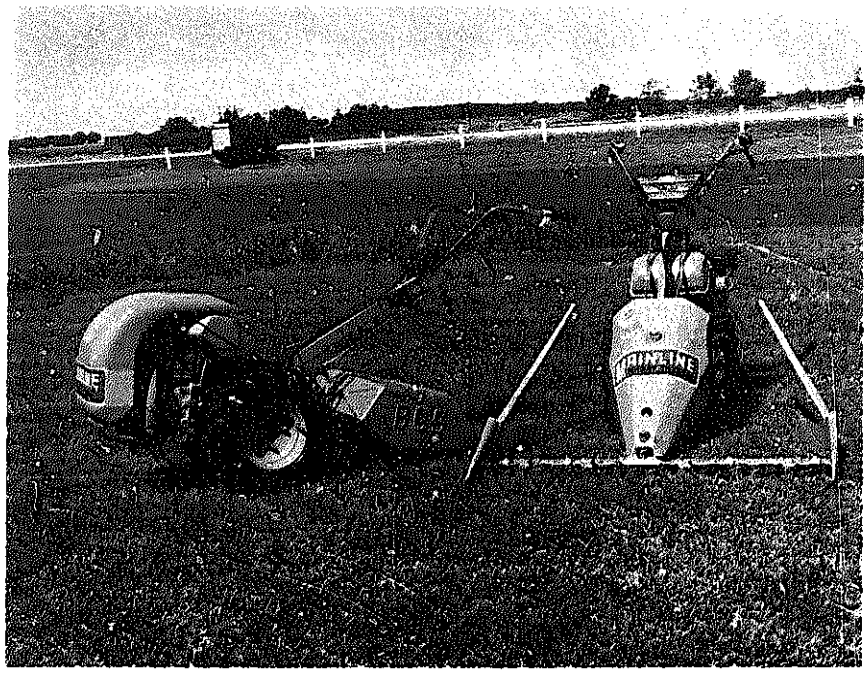
Troy-Bilt
Garden Way Associates, Inc.

The Mainline Tiller *

by Howard Prussack

Mainline is a rotary tiller of high quality and multiuse adaptability. This versatile rear-mounted tiller helps fill the gap between single-use garden tillers and expensive tractors. The basic unit is an 8 h.p., cast aluminum block engine with Pearlite cylinders.

Pearlite is a graphitic process of cast-iron composition, the product being about 20 times the density of regular cast iron, reborable three times. It has an all-gear-drive transmission—no belts or chains. Its automotive design is completely ball bearing throughout, including both ends of the crankshaft.



The standard 8 h.p. power unit with tiller to the left, and the same power unit with gear-driven sickle bar to the right.
Central States Distributors

It is a 20-inch tiller with a heavy-duty cover completely enclosing the tines. There is separate engagement of wheel drive and tiller drive; so the tiller does not rotate (which saves wear and is safer) when transporting. The engine has a power take-off shaft to operate pumps, sprayers, and other attachments that are available, fifteen in all.

The BCS Company, which is in Italy, has been making this tiller since 1963, and it has been designed with the farmer and grower in mind—to take the heavy-duty use and do the different jobs that the attachments make possible.

The extra attachments which make the Mainline more useful for the small grower than any of the other tillers on the market include: a 44-inch sickle bar which can be mounted on the front; combination power hilling and furrowing attachment; a split-row tiller for strawberries and small vegetables; removable tiller so you can add a planter, tool bar, cart, or snowblower.

Mainline tillers come in 5, 8, and 10 h.p. models. BCS also manufactures commercial 16 h.p. rotary tillers which have optional grain binders and thresher attachments. In addition, they make riding tractors which are being imported into this country. The U.S. importer is BCS Mainline in London, Ohio, and the Natural Organic Farmers' Association has contacted them to become the New England distributor.

Central States Mainline Distributors
Box 348
London, OH 43140

* Excerpted with permission from *The Natural Farmer*, February 1977.

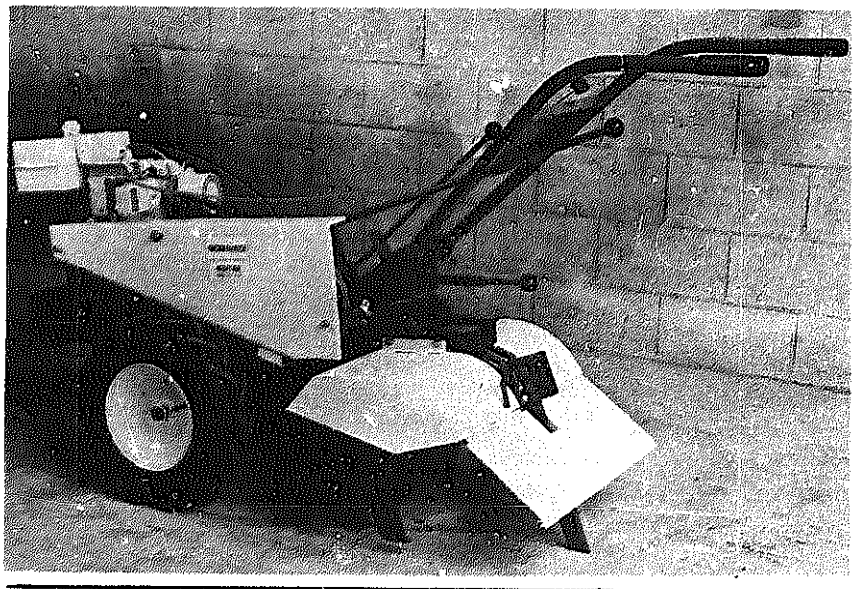
Ariens Rocket Tiller

In the same in-between league as the Troy-Bilt, the Rocket is a 7 h.p. tiller with two forward and two reverse speeds. The rear-mounted tines are 14 inches in diameter and till to a depth of 9 inches. Handles are adjustable for side operation, and the unit is available with attachments for extra-wide tilling and furrowing.

Ariens Co.
655 W. Ryan St.
Brillion, WI 54110



Ariens Rocket Tiller
Ariens Co.



The Mighty Mac 524-RT
Amerind-MacKissic, Inc.

Mighty Mac 524-RT

The Mightly Mac has an 8 h.p., four-cycle engine with a welded steel frame and a chain drive gear. Depth is determined by a manually adjusted drag control bar. Handles are fully adjustable, and speeds include one forward and one reverse. A furrowing kit is available.

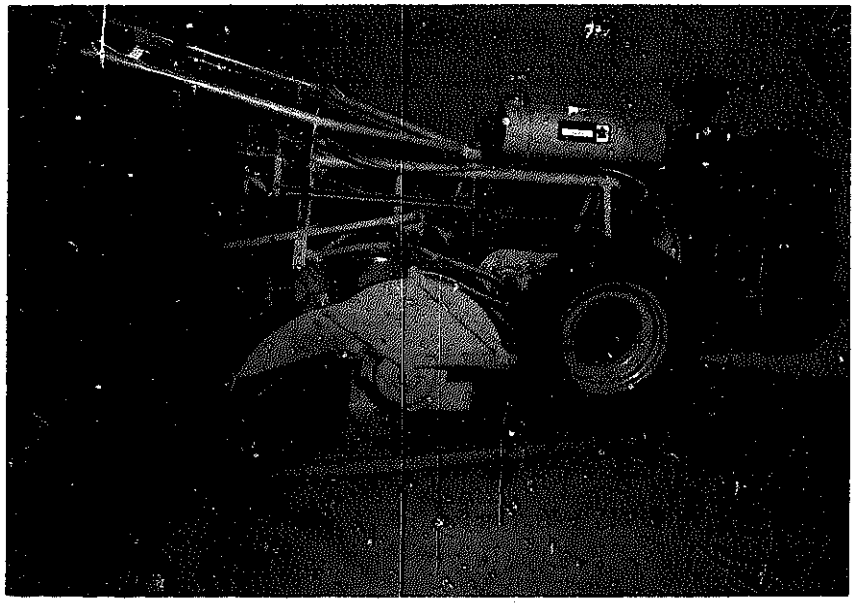
Amerind–MacKissic, Inc.
P.O. Box 111
Parker Ford, PA 19457

Howard Gem

The Howard Rotovator Company specializes in heavier commercial tillers, both walking and tractor-drawn models. They call them rotovators. The larger hand-controlled Gem model is available in varying widths of 20, 24, or 30 inches. A smaller unit, the 350, comes in 16- and 23-inch widths. The transmission on the Gem has three forward and one safety reverse speed with a maximum forward speed of 2.82 mph. Each model is equipped with double wheels for added traction and a depth control wheel adjustable to 9 inches. The optional attachments and accessories include a furrowing attachment and pickline rotor.

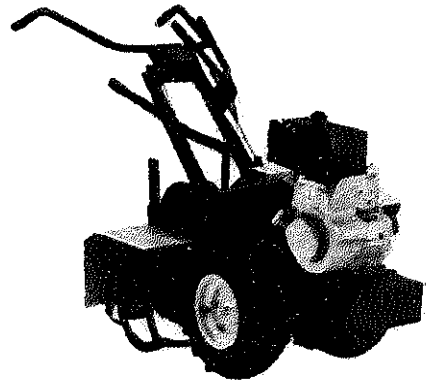
E. C. Geiger
Rt. 63, Box 285
Harleysville, PA 19438

Howard Rotovator Co.
Box 109
Harvard, IL 60033



The Howard Gem
E. C. Geiger

Howard rotovators are distributed throughout the world: Australia, East Africa, France, Germany, Italy, New Zealand, South Africa, the United Kingdom, and Spain.



The Roto-Hoe Roto-Hoe Co.

Roto-Hoe

Roto-Hoes come with tillers mounted either in the rear or up front. A 6 h.p. Tecumseh engine powers the gear transmission with four forward speeds and one reverse. Attachments include a Cut-N-Shred shredder, a snowthrower, and a hiller-marker tool.

The Roto-Hoe Co.
Department 2
Newbury, OH 44065

Herter's Belgian Model 1100 Tiller

Modeled after a Belgian tiller but manufactured in the United States is the Herter Model 1100 rear-end tiller. The transmission is worm gear driven and powered by a 6 h.p., four-cycle

engine. The machine has two forward, a neutral, and two reverse speeds. As a safety precaution, it cannot be locked in reverse. The eight-position depth regulator can be adjusted while in motion, and in the traveling position, tines are raised 2 inches above the ground. No attachments are mentioned. The manufacturer is the only distributor.

Herter's, Inc.
Waseca, MN 56093 or Mitchell, SD 57301

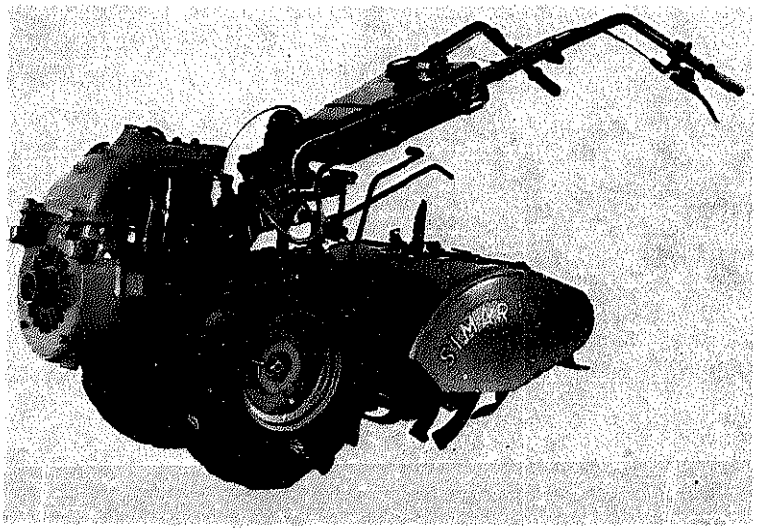
The Simar Morgan

The Morgan is made in Switzerland by the Simar Company and distributed in the United States. It employs a heavy-duty Swill 7½ h.p., one-cylinder, four-cycle engine to power its three forward and one reverse speeds. The unit's weight is 254 pounds. No mention is made of attachments.

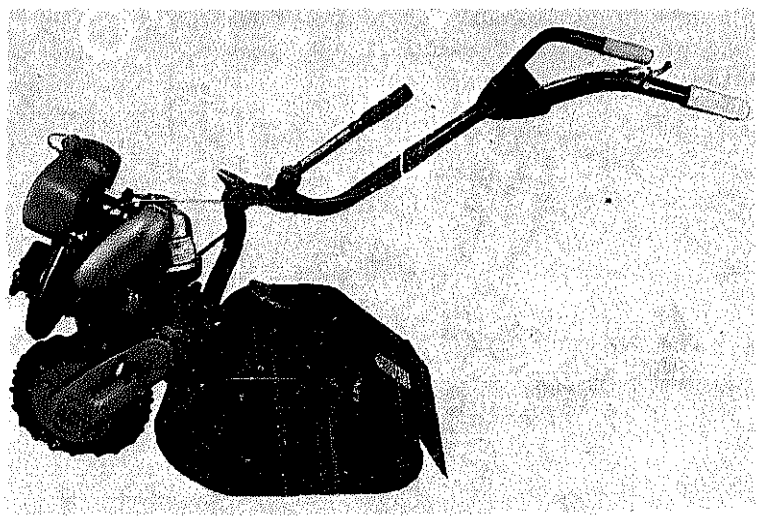
Colt

Of German design, the Colt is a lightweight, rugged tiller for raised benches in greenhouses and outdoor cultivation. It comes with a 10 h.p. engine, an all-enclosed gear drive—no V-belts—and a single power-driven wheel for easy handling. The Colt and the Morgan are available from:

E. C. Geiger
Rt. 63, Box 285
Harleysville, PA 19438



The Simar Morgan
E. C. Geiger

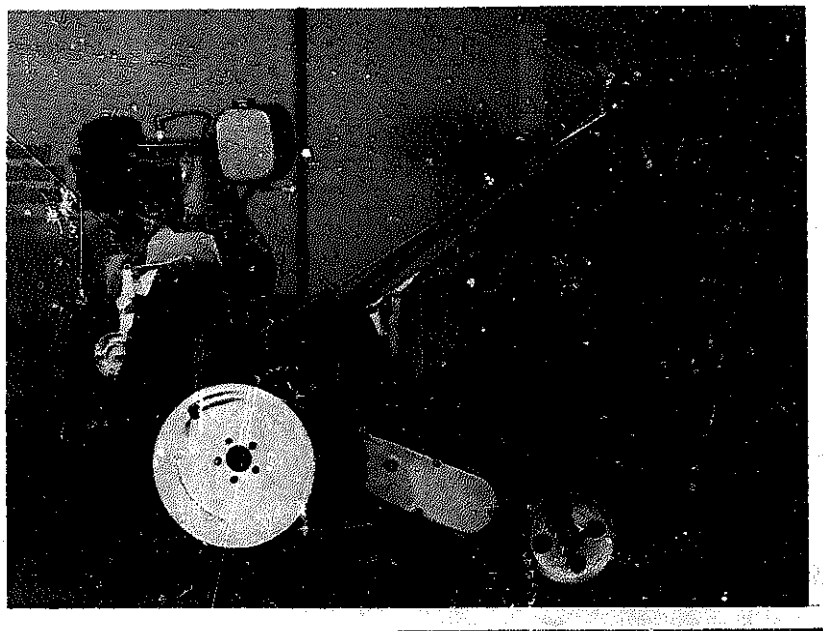


The Colt
E. C. Geiger

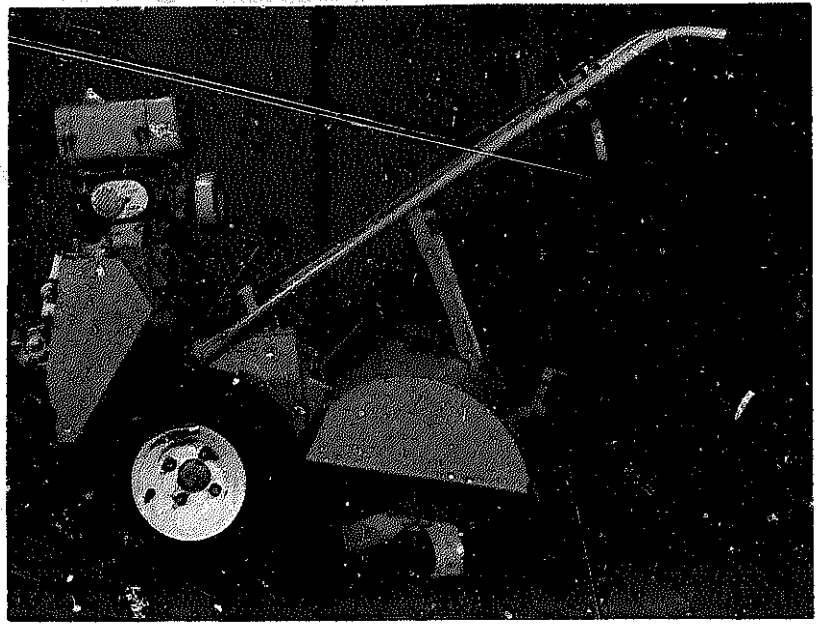
Mang Tillers

Weighing 503 pounds, the Mang Model 95 tiller is designed for heavy-duty tilling jobs encountered by landscapers and nurserymen. The overall width is 26 inches, but it only tills 15 inches at one time. The smaller, 380-pound Mang Junior has a tiller cutter width of 21 inches and is powered by a 7 h.p. gasoline engine. With both models, the strain and shock of the toughest tilling are distributed among the eight sprockets and the heavy-duty roller chain. The manufacturer reports that this feature is unlike most other tillers, where the strain is taken by only two or three gear cogs. There is one forward speed, no reverse.

Oregon Mfg. Co.
6920 SW 111th Ave.
Beaverton, OR 97005



Mang Model 95
Herb Fischborn



Mang Junior
Herb Fischborn

Yellowbird

This unit will rotovate or cultivate with oscillating power tines which cover a 16-inch width.



The Yellowbird Precision Valley Mfg. Co.

Precision Valley Mfg. Co.
Box 9004
Springfield, VT 05156



The Agria Model 2100 Agria-Werke

INTERNATIONAL SOURCES OF REAR-MOUNTED TILLERS

Agria Model 2100

A 7 h.p., two-stroke engine supplies power through one front wheel to drive this tiller. Hooded tillers are available in nine different working widths, and depth is adjustable. It is particularly suited for closely spaced rows. Three-speed tooth wheel gearing is shifted from the handlebar. Its weight is 80 pounds, and provisions are available for adding front weight. Attachments include a ridger, a leaf protector, and a cultivator.

Agria-Werke Gmbh
7108 Moeckmuehl
Germany

Buffalo Tillers

Three models are available. The 14 h.p. model weighs 335 kilograms, the 9 h.p., 235 kilograms, and the 7 h.p. model, 205 kilograms—



Tiller attachments come in varying widths, interchangeable for the specific requirements of each cropping situation. Hako

all without engine. All three have four-cycle, air-cooled, diesel engines, hand-cranked starting, and three speeds for both forward and reverse. With rotary tiller, capacities range from ¼ to 1 acre per hour and with plow, from ⅓ to ⅔ acre per hour.

Three Farmers Machinery Co., Ltd.
No. 37 Min Chuan St.
Wu-Chi Taichun Hsien
Taiwan, Republic of China

CeCoCo Suzue Power Tiller Model LEC-50

Two types of engines are available: a water-cooled diesel with 6 or 7 h.p. or an air-cooled, gasoline engine with 6 to 8 h.p. There are six forward and two reverse speeds. Road clearance is a minimum of 178 millimeters, and it weighs 250 kilograms. Power take-off speeds are changeable with two or four steps. A safety device keeps reverse from engaging until the rotary blades have stopped. It has an adjustable handle.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

STATIONARY WINCH-POWERED CULTIVATION

Prior to the invention of the tractor, about the time of World War I, cable cultivation was the only form of mechanized agriculture for about 75 years, and this represented the first use of steam power for cultivation. Because the first steam engines were not self-propelled, a scheme employing a cable and windlass was used to get the plow from one end of the field to the other. The cable usually wound on a horizontal drum beneath the engine which was driven by bevel gearing from the engine shaft.

Though the most expensive initially, the most satisfactory implementation of this technique utilized two steam engines. One engine pulled the plow through the field while the other paid out slack cable and moved ahead into position for the next haul. As steam engines became lighter, it became more feasible to use them as tractors to pull implements through the soil, and the need for a cable disappeared. Today, cable cultivation is used on small, steep plots in France and Italy, and for plowing paddy fields in China. Agricultural engineering researchers recognize the winch as a significant tool worth developing in their quest for simply designed machines to satisfy the worldwide need for economical, energy-efficient field mechanization. Mechanical Engineer Stuart Wilson from Oxford outlines the reasons why.

"The three very considerable advantages of cable cultivation compared to conventional tractor use are:

1. Lower energy consumption due to elimination of both wheel slip and the energy needed to transport the prime mover.
2. No compaction of the soil, an increasing problem with large tractors.
3. Ability to plow in wet or slippery conditions.

The disadvantages include the need for two prime movers if the most effective method is used and the need for some sort of reversible plow."

Wilson continues, "However, in light of the fact that plowing is only a small part of the average tractor's use and that most of the remaining duties, especially road haulage, need much less than maximum power, there appears to be a case for evolving a design for a basic tractor of modest power which can be used in pairs for cable plowing when required, but is otherwise capable of performing a variety of lighter duties."

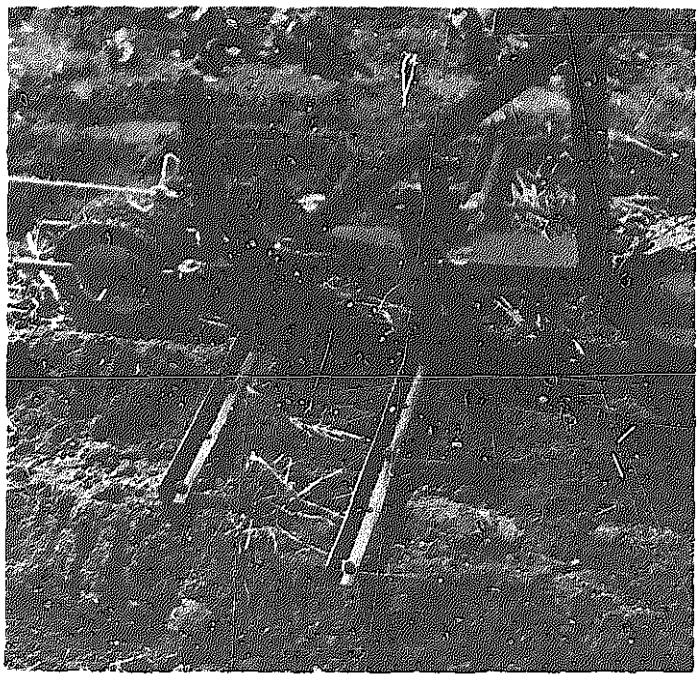
Three designs are on the drawing board to utilize winch cultivation: a pedal-powered Mechanical Mule, a two-wheeled tractor called the Snail, and a three-wheeled tractor, the Spider.

The Mechanical Mule

Designed by Rodale Resources, Inc., in Emmaus, Pennsylvania, the Mechanical Mule harnesses the power of the pedal to provide winch-pulling power for farm tilling tasks. The power unit seen in the photo on page 60 is positioned at the head of a row while a toolbar carrier is positioned at the foot of the row.



The Mechanical Mule



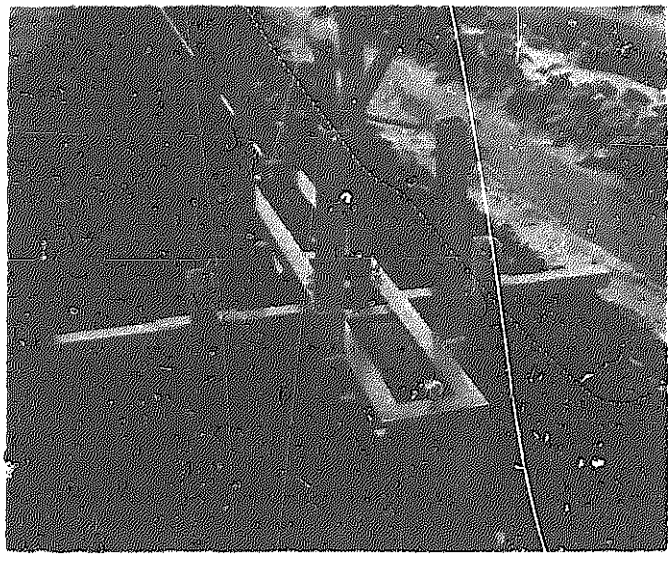
Mechanical Mule tool carrier with cultivator attachment.

As the operator of the power unit pedals, a high-test nylon or polypropylene line fastened to the tool carrier is reeled in and the tool carrier, guided by a second person, is pulled up the row.

When one row is completed, the helper walks the tool carrier to the foot of the next row, unreeling the power line as he walks. Simultaneously, the pedaler moves the power unit to the head of the next row. When everything is in place, the operation is repeated. This multipurpose implement can be used for plowing, subsoiling, harrowing, and row-making, as well as cultivating. Tools are quickly interchangeable for tending three rows at a time.

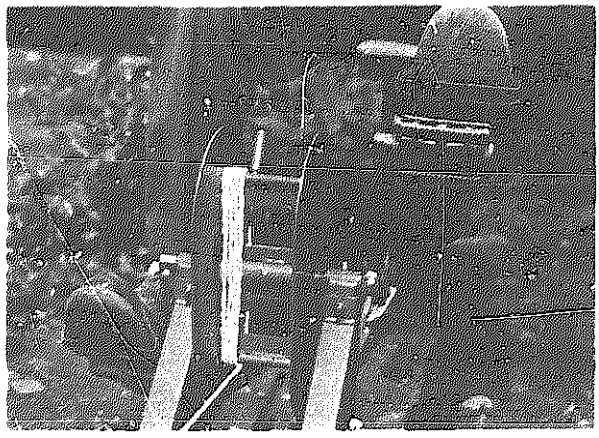
The tool carrier is light enough to avoid compacting the soil and narrow enough for minimal row spacing for intensive crop production. Such intensive cropping systems tend to reduce the need for frequent weeding, as the tightly spaced plants help to shade out the weeds.

Dynomometer tests reveal that an average man can exert a pull of 1,000 pounds with the aid of the Mechanical Mule. From a sitting position, the energy of the strongest human muscles, those of the thighs, is relayed through a bicycle crank mechanism to maximize leverage. With spacer bars on the uptake reel, the effective diameter is increased for reeling in several feet of power line with each revolution of the crank—the equivalent of high gear. For harder jobs, the spacer bar can be removed for reeling in only a few inches of line with each revolution of the crank—the equivalent of low gear. Pulling speed is reduced, but pulling power is about doubled.



The row-making tool simultaneously prepares three rows for planting 12 inches apart, facilitating intensive cropping systems.

Spacer bars on the uptake reel of the Mechanical Mule reel in several feet of power line with each revolution of the crank—the equivalent of "high gear."



In the interest of safety, to keep the crank from slipping backwards and the pedals from hitting the operator in the shins, a ratchet-brake mechanism was built into the unit. Depressing a clutch disengages the reel from the crank so the power line can be easily reeled out.

Rodale Resources Division
576 North St.
Emmaus, PA 18049

The Snail

The Snail, a primary cultivation device, was developed at the National College of Agricultural Engineering, Silsoe, Bedford, U.K., as a possible solution to the problem of cultivating hard, dry soil in developing countries during the dry season, so as to achieve early planting with increased crop yield the result, reports Peter Crossley.

The machine overcomes the energy constraints of human or animal power, is much cheaper than a large tractor and more efficient than a small one. The principle utilized is that of a self-propelled winch controlled by one operator, together with an implement mounted on a frame and controlled by a second operator. The winch unit is driven forward to the extent of its cable, drive is engaged to the winch drum, and the cable draws the implement towards the winch unit, which is prevented from moving backwards by a self-anchoring sprag.



The Snail
National College of
Agricultural Engineering

In tests during the dry season in Malawi, sponsored by the Ministry of Overseas Development, the machine was found to work satisfactorily in most small farm conditions, and would be likely to be economical in areas where alternative cultivation methods were either unavailable or more expensive. It is designed to operate in hard soils and would not be technically satisfactory in wet land or in temperate areas.

The Spider

The Spider is a three-wheeled, self-propelled winch-tractor which evolved from the Snail and the Kabanyolo. In an article entitled "Are Small Tractors Possible?," * Peter Crossley reports that the Kabanyolo was an example of the "ingenious use of mass-produced components in a chassis which was designed to be manufactured locally from stock materials." He describes the Snail as an example of "a small, self-propelled winch, which provides a much higher draft force than a single-axle tractor of corresponding size and weight." When the limitations of these two units were clearly defined, efforts were directed at combining the best features of both in the design of the Spider.

Still in its early stages of testing, the Spider is being developed at the United Kingdom's National College of Engineering in Silsoe, England.

Crossley states that "the Spider consists of a fabricated chassis, on the front of which is mounted a 6.5 h.p. diesel engine, which drives the two rear wheels by means of a V-belt and

* *World Crops and Livestock*, May/June 1977.



The Spider
National College of
Agricultural Engineering

chain reductions. In the center of the rear axle is a winch drum. Steering is tiller operated on a single front wheel, and the rear track is 1 meter wide."

"It was anticipated that light-draft operations would be carried out by direct traction with mounted implements at speeds of up to 4 mph, but that for high-draft work, the machine would be operated in the same manner as the Snail, by driving forward to the extent of the cable and then winching in the implement."

Now, even before testing has been completed on the Spider, plans are being drawn up for an improved design. Crossley continues, "The proposed design is that of a lightweight, three-wheeled tractor having 6.00 x 16 rear-drive wheels spaced at a 2-meter-wide track with a single 4.00 x 12 wheel at the front. The five kw. engine would be transversely mounted in front of the rear axle, the drive being supplied by a chain reduction. Further, enclosed chains would drive each rear wheel from the outer ends of the high-mounted axle, in the right-hand section of which would be mounted a winch drum. Good ground clearance and lateral stability would therefore be obtained. A sprag and guide roller device would act in line with the winch so that the tractor could be driven with the right-hand rear wheel in the furrow, in the conventional manner, for winched operations such as moldboard plowing. A patent has been applied for."

"No differential would be fitted, but as with the original Spider, either or both rear wheels could be engaged by means of dog clutches, thus allowing both wheels to be driven during light cultivation operations, or while moving forward prior to winching. In order to turn at headlands, the inner wheel would be declutched, allowing sharp turns to be made; a reverse gear would not be required. By adding a second primary chain and dog clutch, an additional forward speed could be provided for transport work."

"Although lightweight, the Spider would optimize its performance for low-draft operations by virtue of its axle characteristics and reasonably sized drive wheels. The track spacing and high ground clearance would allow it to work in ridges. During high-draft winching operations, the machine would work slowly but effectively, and with the addition of a second man on the implement, could undertake operations which no small tractor of equivalent size could attempt in poor traction conditions."

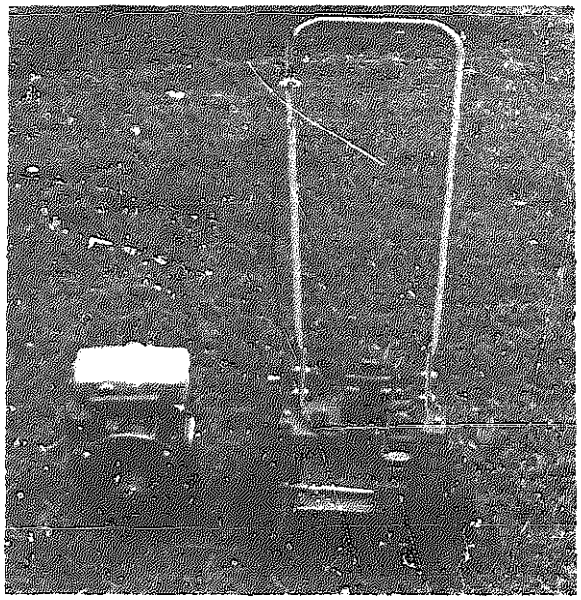
Such design work by the National College of Engineering is aimed at increasing the agricultural productivity in developing countries. One criticism of this final design is the complicated operation procedure. Present thoughts

include considering a switch to hydrostatic transmission which would simplify operation, but increase cost and decrease efficiency.

UNIQUE CULTIVATION DEVICES

Kuranda Rotary Cultivator

The Australians have devised a cultivation unit which can be powered by any four-stroke gasoline engine to cultivate to a width of 14 inches. Other attachments are available for quick interchange of the engine, including a posthole digger and litter vacuum.



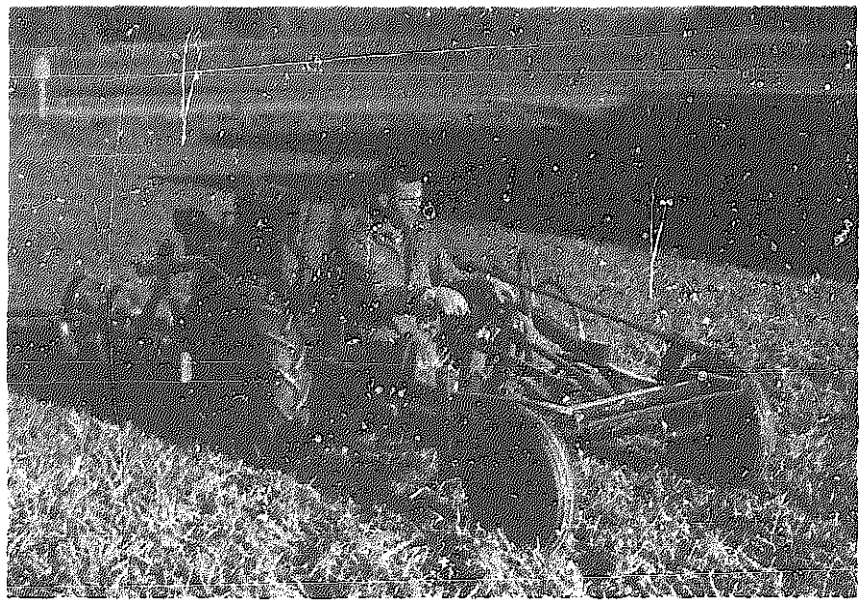
Kuranda Rotary Cultivator Kuranda Industries

Kuranda Industries Pty., Ltd.
42 Bank St., P.O. Box 26
Padstow 2211, Australia

The Friday Self-Propelled Power Hoe

The Friday Self-Propelled Power Hoe is a 9 h.p. tractor specially designed for hoeing around individual plants rather than only between rows. It is guided with individual turning brakes, thus leaving your hands free to operate the controls for the hydraulically powered hoe blades. Though specially designed with strawberry cultivation in mind, it is good for all row crops. It is particularly suitable for the organic farmer who would prefer to cultivate around individual plants rather than use herbicides.

Three different types of hoeing blades are furnished with each machine. An adjustable weeder will comb runners of young strawberry plants without damaging them while dragging out small weeds and leveling the ground. One hydraulic valve raises or lowers the cultivator, weeder, or hand hoes and also controls the fertilizer attachment.



The Friday Self-Propelled Power Hoe
Friday Tractor Co.

The 9.2 h.p., air-cooled engine powers one reverse and three forward speeds for a range of ¼ to 7 mph. Low rates of speed are necessary for thorough hoeing. The hoe has a 13-inch crop clearance and weighs 1,210 pounds. A fertilizer attachment and electric starter are available options.

The manufacturer claims that one man can cultivate, hoe, weed, and fertilize a whole acre in 2 hours. At this rate, he can assume responsibility for caring for 25 acres of strawberries.

Friday Tractor Co., Inc.
Hartford, MI 49057

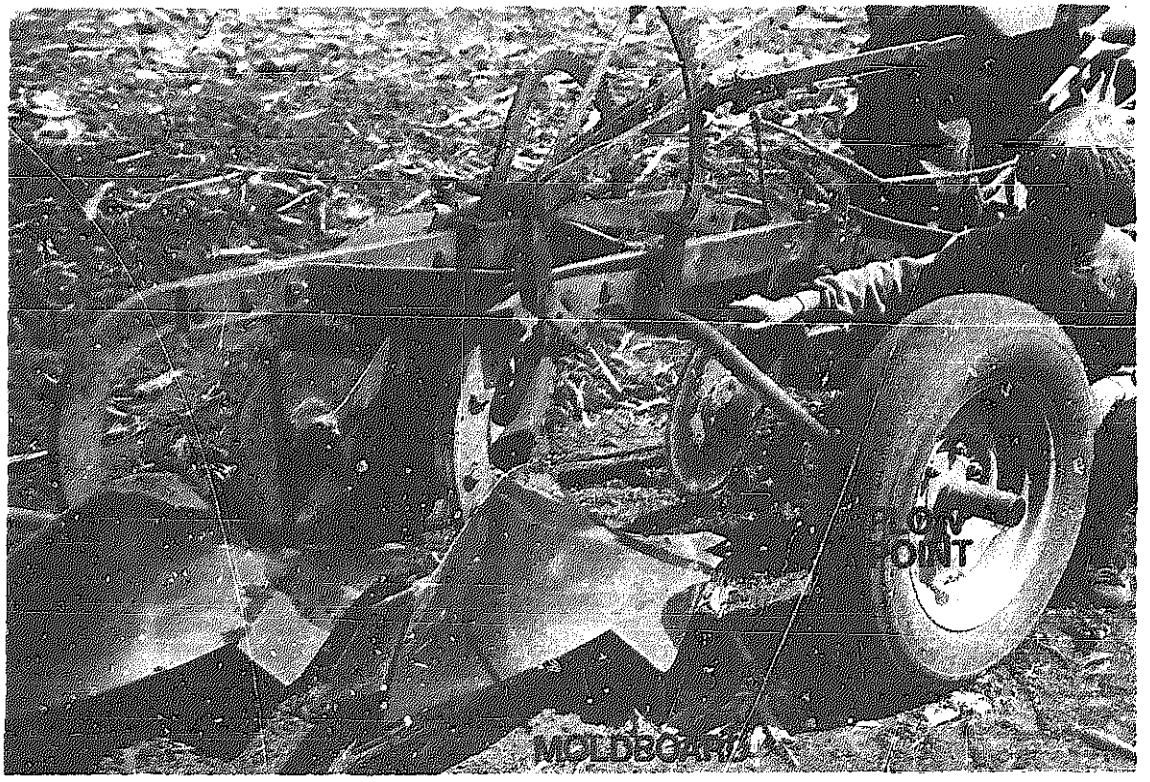
PLOWS

Farmers through the ages have devised almost every conceivable type of soil-working tool—from nothing more than a tree branch dragged over the soil to level it, to sophisticated, spinning steel knives churning through the ground. Some inventions work; some do not. Some work better in certain soils than in others. Some work better in wet years than in dry, or vice versa. But be assured that whatever idea for tilling soil you may have, someone, somewhere, has the tool for it.

THE MOLDBOARD PLOW

The moldboard plow is the traditional power tool for opening or breaking the ground in preparation for planting. Characteristically, the moldboard, from which this type of plow gets its name, turns dirt completely over as the plow is pulled along, burying surface plant material and leaving soil bare, loose, and easily worked into a seedbed. Most moldboard plows have solid moldboards, though slotted moldboards are also made and used in some soils.

Some organic farmers think the moldboard plow is an undesirable tillage tool and put their faith in offset discs. This argument has been going on for over 50 years and won't be settled for 50 more. In the meantime, just remember that on a small, noncommercial

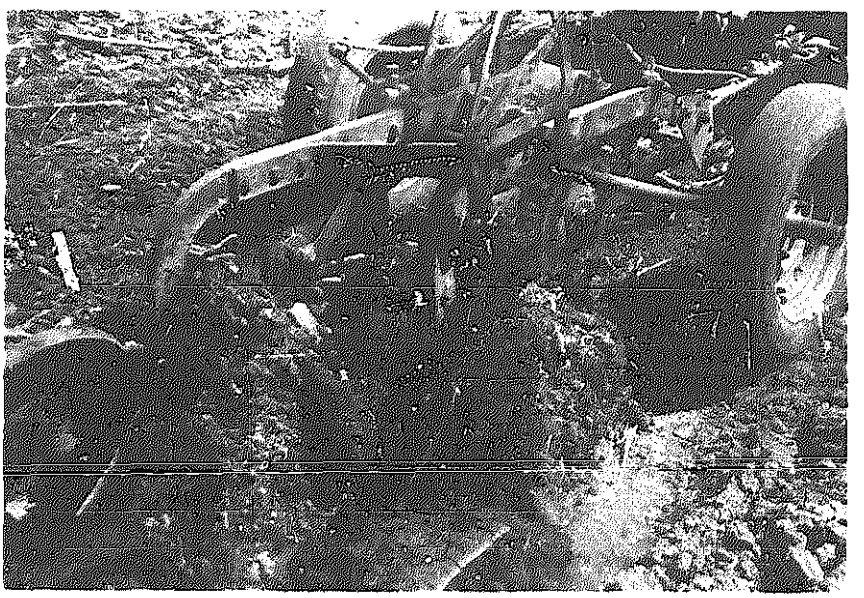


The only drawback of the moldboard plow is that it can cause greater erosion. The boy has his hand on the slicing coulter.

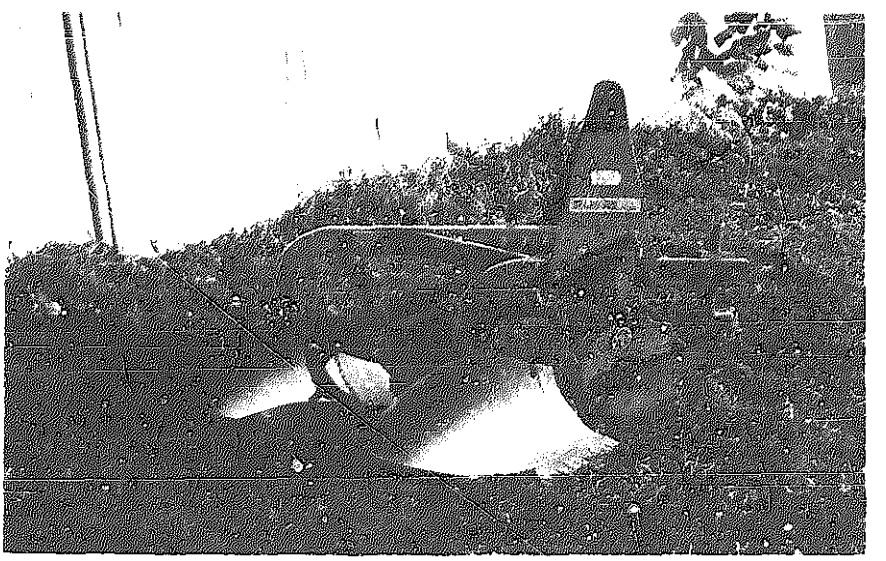
homestead, an old plow costing under $50 is adequate, while even the smallest, used offset disc, heavy enough to really chop up and incorporate crop residue and green manure into the soil, will cost you 10 to 20 times that much. The only drawback to the moldboard plow you will need to remember is that it can cause erosion. Don't plow steep slopes and don't fall-plow even gentle slopes with a moldboard plow.

Size is the first consideration when shopping for a used plow. For a two-bottom (two plows), 14-inch model, you need at least a 25 h.p. tractor, and 35 would be better. (The 14-inch measurement is the width of the furrow each plowshare makes.) A 15 h.p. tractor will pull a single 12-inch plow. (One of the editors of this book, Gene Logsdon, recommends not going smaller than a 14-inch plow for field work, but this is a matter of personal preference. He finds that the smaller plows aren't heavy enough to satisfy him, especially for turning under green manure crops.)

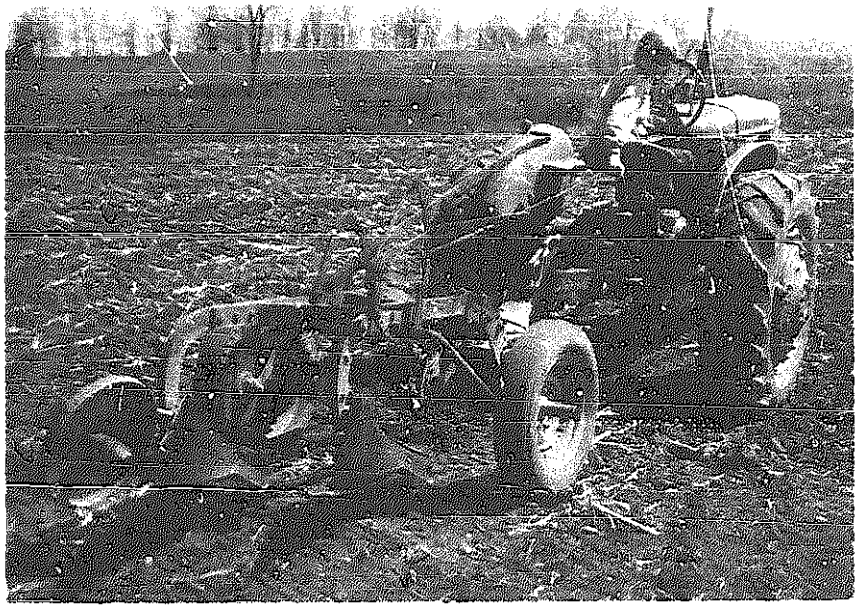
You may also have to decide between a mounted plow and a pull-type plow. Mounted plows attach to the tractor in such a way that



Coulters cut, moldboards turn the soil over, and a wheel to the rear adjusts the plowing depth.



The two-bottom plow does a good job on plots of ten acres or less.



Here the pull-type plow is in a raised position with its rear wheel completely off the ground.

they can be raised completely off the ground for ease in backing into tight corners of small fields or garden plots and in transporting them over the road. They are more difficult to attach to the tractor than are pull types, require a power take-off connection and/or hydraulic pump, and are more expensive.

Pull-type plows hitch and unhitch rather easily by comparison and are cheaper, but they are far less maneuverable. On some two-bottom pull-types, the rear wheel lifts completely off the ground when the plowshares are in the raised position. That's a desirable characteristic, since it lets you back the plow as easily as you can a two-wheeled trailer. When you cannot back up a plow, it is almost impossible to work small areas or tight corners where turning space is very limited.

The older two-bottom plows are all pull types and are perhaps a better buy for the money, even if they are a little awkward. Few of them are worn-out—they just become obsolete. A cog and gear mechanism powered by the revolving left wheel of the plow raises and lowers the plowshares when activated by pulling a trip rope. When you come to the end of the field, you tug gently on the rope and the plow lifts out of the ground. Another gentle tug and it drops into the furrow again. The tripping mechanisms probably wear out sooner or later, so you should check before you buy.

Most likely, the plow points will be dull, and you will have to get them sharpened or buy new ones. When you order new ones, you will need to know the name and model of your plow.

Check the two levers on the plow. Each lever raises or lowers the wheel closest to it. The shorter lever over the furrow wheel sets the depth of the plowshares, while the longer one levels the pitch of the two plows so that they plow evenly at whatever depth. Sometimes the levers are broken, cracked, or bent, especially the shorter one, from trying to adjust plow depth while the plows are in the ground. Always make the short lever adjustment with the plows raised. The long lever can be adjusted from the tractor while you are in motion.

The lever handles have a hinged piece which you squeeze against the main handle to lift the lever pin out of the slot that it's in. With the slot pin lifted, you can move the lever up or down. The lever pin may be rusted tight, or the spring that keeps proper tension on it may have become rusted or broken. All are fairly easy to repair.

Perhaps the most important point is to be sure each plow point is preceded by a coulter—the disc that slices off the soil which the moldboard will turn over. Coulters are easy to take



This is how to adjust the short lever for depth.

off of one plow and put on another plow: hence, they are easily lost. An old plow may cost only $10, but if the coulters are missing, replacements are liable to cost you $50 or more.

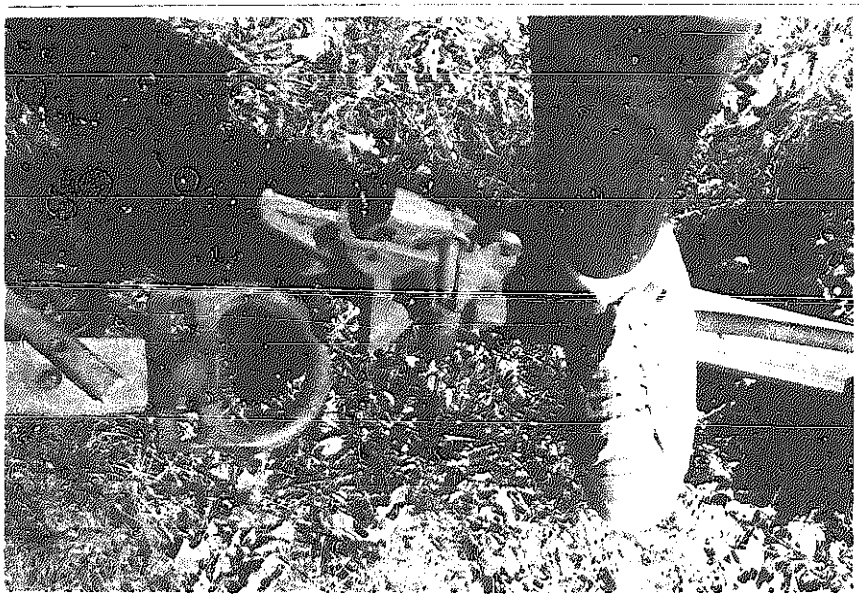
Next, check the condition of the moldboards and plow points. If the surfaces where the dirt slides are very rusty and pitted, you will have a difficult time getting the plow to scour. Dirt will stick to the steel, and the plow won't be effective. If there's only a little rust or shallow rust, it will wear off quickly when you plow, leaving the shiny, smooth steel surface necessary for good plowing. Better yet, an old plow that has been cared for will have its moldboards and plow points covered with a coat of grease or oil when not in use to protect against rust. Be sure you treat your plow surfaces to the same protection between plowing seasons.

A rusted moldboard may be reclaimed with fine sandpaper and rust remover, but if badly pitted, it will never scour very well. Look for another plow.

You want the plow to make even furrows, not every other one higher or lower. If the latter condition prevails on your plowed ground, keep changing the lever positions until the turned furrows all look level with each other. Remember that the right wheel runs in the furrow four to six inches lower than the left wheel if you are plowing four to six inches deep. So when you make your first pass across the field, there is no furrow for the wheel to run in, and therefore you need to adjust the plow depth lower. Otherwise, the front plow won't go deeply enough into the ground. On the second round, you will have to readjust, because then the one wheel will be in the furrow. Likewise, on your last round, when you are finishing a dead furrow, the other wheel will drop lower than normal, and you will have to adjust the depth again. If you don't, you will gouge out too deep a dead furrow.

Pull-type plows require a special clevis to attach them properly to the tractor drawbar. The clevis is first bolted to the tractor drawbar; then the tractor is backed up to the plow tongue, and the clevis is pushed into the hooded plow hitch until it latches—you can hear the click. If you are alone, with no way to lift the plow hitch up in line with the clevis so you can back the tractor into it, you will learn how to stop at just the precise distance from the plow hitch, get off the tractor, lift the hitch or push down on it, and force it into the clevis.

The reason for the somewhat complex hitching mechanism on a pull-type plow is to keep the plow from breaking should you hit a root or stone underground. When that hap-

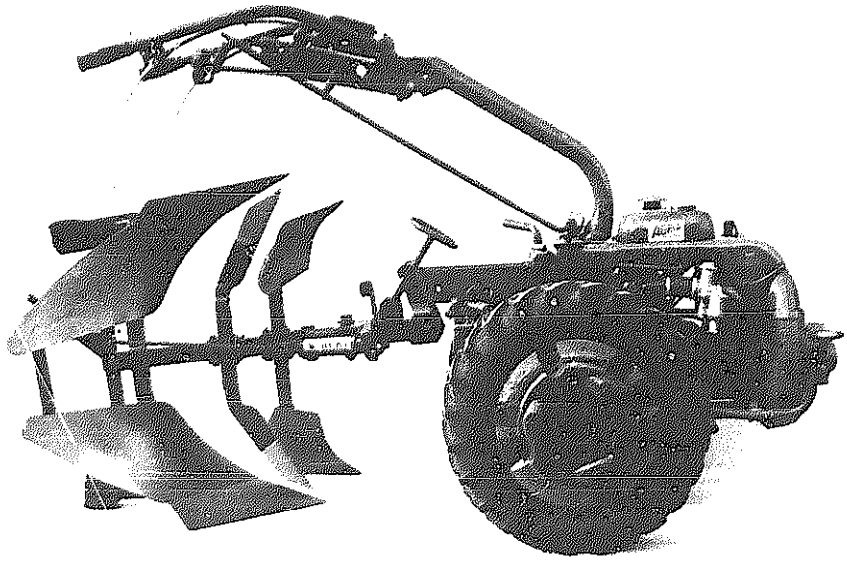


The plow hitch is seen here just before it is coupled to the clevis.

pens, the jolt makes the hitch fly open automatically, and the plow, unhitched, stops immediately, saving many repair jobs.

For that same reason, don't tie the trip rope too tightly to the tractor seat. Loop it through a weak hook of wire so that if the plow comes loose, the rope will too. Also, leave plenty of slack in the rope so that it doesn't tighten up and trip the plow when you are turning at the end of the field.

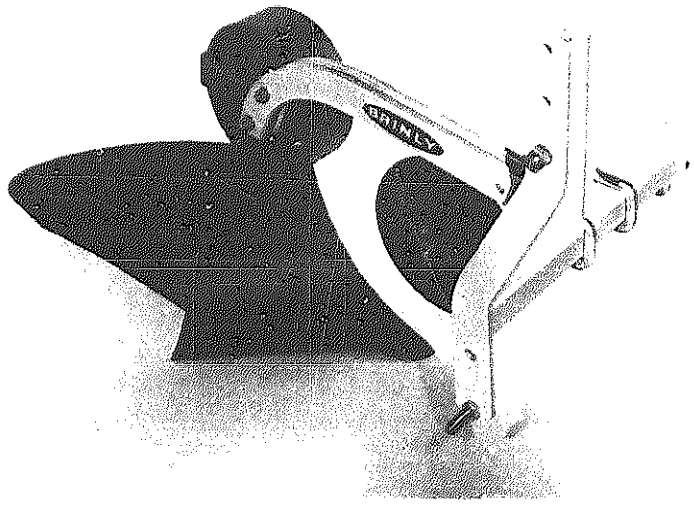
Because of the way a plow works, you can't just root the soil up any way you please. A plow lifts the soil from one place and deposits it eight to twelve inches to the side of its original position. The ditch that is left is called a furrow. After the first pass across the garden or field, the furrow ditch is there to throw the dirt into from the second furrow and so forth. When you are finished plowing, you will have at least one furrow left over. This is called a dead furrow. Naturally, the first time you plow across the field or garden, you do not have a furrow already there. So the dirt turned over by the plow blade falls on the normal soil sur-



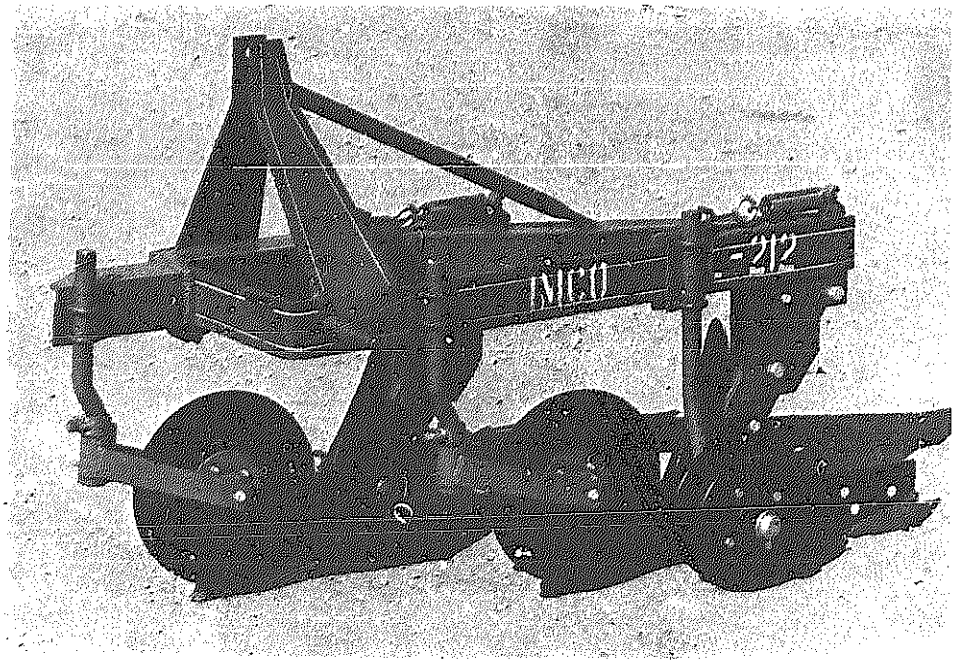
The Hertecant two-way, reversible plow attached to an Agria two-wheel tractor. Willem Hertecant

face, leaving a ridge of dirt. This ridge is called a headland. The art of plowing demands that in subsequent years of plowing, you make your headlands fall where last year's dead furrows were, and last year's headlands then become this year's dead furrows. If you don't do that, your field will become less level every year.

Commonly, moldboard plows are one-way plows, but two-way plows are made, and they are often called hillside or reversible plows. A two-way plow has two sets of plows, one above the other. At the end of the furrow, the operator can flip the two over, so the top will swing down in plowing position and the bottom will swing up out of the way. He or she can then proceed to plow back in the same furrow just made, which would be impossible with a one-way plow. The two-way plow eliminates dead furrows and headlands and is very handy when plowing terraces or contours on hillside land.



For 14 and 18 h.p. garden tractors equipped with category 0 three-point hitch, the Brinly-Hardy 12-inch moldboard plow features an adjustable gauge wheel with scraper to control plow depth in varying soil conditions; a throwaway share for lower replacement costs, 11-inch adjustable coulter, and adjustments for landing and width of cut.
Brinly-Hardy Co.



A line of moldboard plows may be used with either the spring trip or as a shear-pin type plow. Coulter blades and gauge wheels are available as optional equipment. Plow models include a one-bottom 16-inch plow, a two-bottom 12-inch plow, or a two-bottom 14-inch plow.
Independent Mfg. Co.

NORTH AMERICAN SOURCES OF MOLDBOARD PLOWS

	SINGLE-BOTTOM MOLDBOARDS	DOUBLE-BOTTOM (or more) MOLDBOARDS	REVERSIBLE MOLDBOARDS	SPARE PARTS & ACCESSORIES	DISC PLOWS
ALLIED FARM EQUIP. (KVERNELAND)		X			
BRINLEY-HARDY	X				
J. I. CASE		X			
CHROMALLOY FARM & INDUSTRIAL EQUIPMENT CO.				X	
CORSICANA GRADER & MACHINE CO.	X	X			
IMCO (INDEPENDENT MFG.)	X	X			
INTERNATIONAL MODERN MACHINERY, INC.	X	X			
SPEECO (SPECIAL PRODUCTS) available from T3C & CENTRAL TRACTOR	X	X			

INTERNATIONAL SOURCES OF MOLDBOARD PLOWS

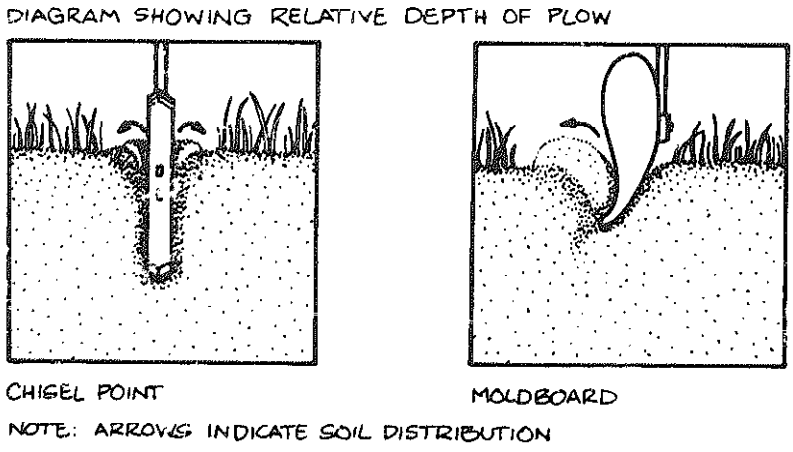
ACM EQUIPMENTS	X		X		
AGROMET MOTOIMPORT		X			
BEAUVAIS & ROBIN	X	X	X		
CECOCO	X	X			X
FISKARS		X			
FRANK'SCHE EISENWERKE				X	
GHERARDI JESI	X	X	X		X
W. HERTECANT	X		X		X
HUARD-VCF-SCM	X	X	X		
INDUSTRIAS METALURGICAS APOLO S.A.					X
KVERNELAND		X			
NARDI MACCHINE AGRICOLE	X	X	X		
PIERCE OF WEXFORD		X			
SYNDICAT DE L'OUTILLAGE AGRICOLE ET HORTICOLE				X	
TONUTTI S.P.A.	X	X	X		

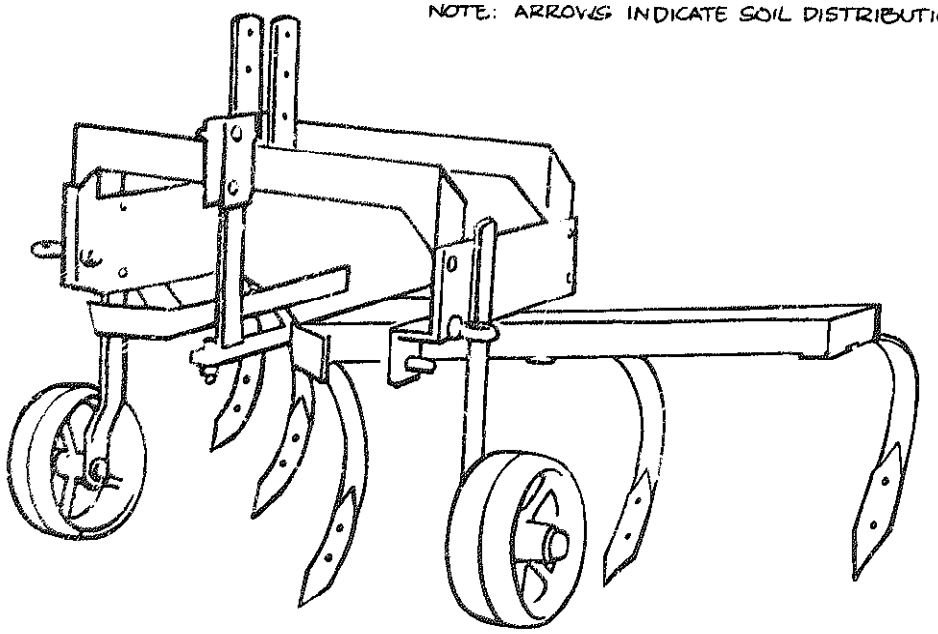
THE CHISEL PLOW

Challenging the moldboard plow for the lead in farmer popularity, especially in hilly and dry country, is the chisel plow or the very similar field cultivator, sometimes called simply the digger. This plow consists of sets of curved tines or small shovels which dig up the soil to a depth of 12 to 18 inches, loosening and lifting it, but not turning it over like a moldboard plow does. The chisels are shaped in an arc, something like the letter C so that the point penetrates the soil ahead of the shank. Chiseled ground is not nearly as subject to wind or water erosion as moldboard-plowed soil. Some plant material remains on or near the surface to hold the soil in place.

Chisel plows come in several designs, either with twisted shovels or straight shovels. Straight shovels are usually two inches wide, while the twisted ones vary up to four inches wide. Twisted shovels tend to stir and mix the soil more than the straight type and are used when heavy plant residues need to be incorporated into the soil.

Most chisel plows demand big tractor power. A 13-foot chisel operating ten inches deep at five miles per hour requires 120 horse-

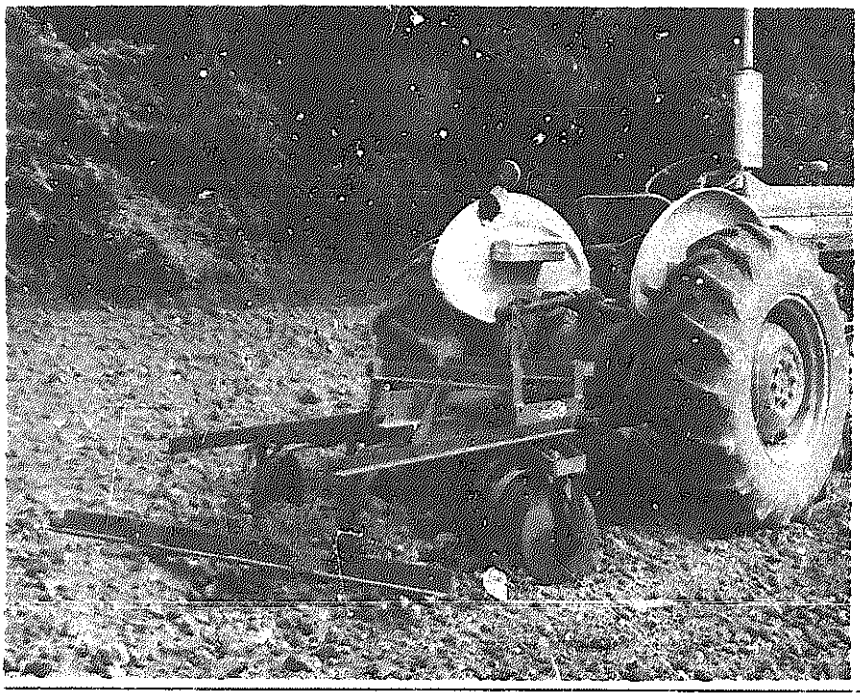




A chisel plow with depth wheels.

power. However, most chisel plows are put together so that you can remove individual blades (or shanks) to reduce the pulling load.

To avoid jamming plant residues in front of the blades, which can happen where surface trash (organic crop residue) is heavy, manufacturers have combined the disc and the chisel plow—a series of straight coulters in front of the chisels to cut up the plant residues. You don't have to use a stalk chopper or disc ahead of this kind of chisel. But it requires a large tractor to pull it.



The Cole 510 system for chisel disking with four springs, center spring, six discs, and a smoothing drag for category 0 and 1 three-point hitches.
Cole Mfg. Co.

FARMING ORGANICALLY WITH NO-PLOW TILLAGE

After 27 years of organic farming, the Mundt family in Michigan has developed a unique combination of green manuring and no-plow tillage to stop erosion and grow better crops. They're building humus, high-quality soil, on a sandy, hill farm. To incorporate the lush growths of sorghum-sudan grass, the solid-stand corn, and buckwheat, Bill Mundt uses a heavy, offset disc. It almost seems to work miracles in the sandy ground. Two passes, the second at right angles to the first, over a jungle of eight-foot-high sorghum-sudan, and the plants are incorporated into the soil, ready for a broadcast seeding of buckwheat or rye. After the seeding, another pass with the disc covers the seed, levels the surface fairly well, and firms the soil to sprout the seed. But still the ground is thick with chopped organic matter which reduces erosion to a minimum. The soil is so biologically alive that the rotting process of the incorporated leaves and stalks begins immediately. Each year the sand becomes richer in humus. "It works. The best proof I have is that I'm raising fairly good crops right over areas that were stone-filled gullies 30 years ago," says Mundt.

His other main cultivating tool is the field cultivator or chisel plow (some farmers call it a digger or chisel), which can be set deep to open up the ground. On grain stubble, sod, hay field, corn or bean fields after harvest, the chisel can be used as a primary tool to break the ground as well as plow it, but without turning it completely over on the surface and allowing easy erosion. Fall-chiseled soil can be gone over with a disc in the spring and planted. Two chiselings, the second at a right angle or bias slant to the first, can be planted with a drill, pulling a disc ahead of the drill. Or it can be broadcast-



To prevent loosened plant trash from chiseling the second time through, Bill Mundt uses "beavertail" ripper blades which are six inches wide—wider than regular chisels.

planted and covered with the disc. "For a plowdown crop, you don't need to have a smooth soil surface. Leaving it a little rough catches and holds moisture better," says Mundt.

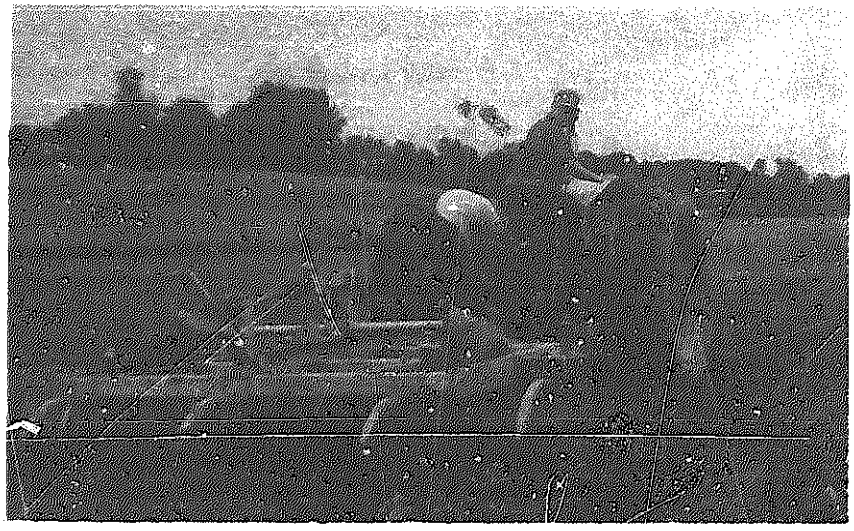
When incorporating heavy trash, field cultivators are apt to plug up. "The first time through you're okay," points out Mundt. "But the second time, the loosened plant trash will collect in front of the chisels. To prevent that, I use what are called beavertail ripper blades. They are six inches wide—wider than regular chisels. What they do is throw dirt ahead of them in enough volume to prevent the jamming of plant material on the blades. You have to drive fast to get the proper action." If plugging still persists, or if you want to dig the ground so deep the tractor won't pull your field cultivator, you can remove every other blade and still do a fairly adequate job of primary cultivation.

Neither offset disc nor chisel is a machine for small tractors. "Figure you need five to eight horsepower for every foot of width of your tool," says Mundt. Since ten feet is about minimum width for standard American offset discs and chisels, you're talking about a tractor of at least 50 horsepower for the smallest models.

Mundt sometimes uses his chisel after the disc. "Where erosion is a bad problem, you can cultivate lightly with the disc a couple of times and chop the trash into the top layer of the soil. Then, with the trash on top to protect the soil, you can go deep with the chisel and open the ground without burying the top mulch."

Working with large amounts of plant matter can cause problems when you are cultivating weeds in row crops. Plant material collects on cultivator shovels. "High-clearance sweep shovels are one way around the problem," says Mundt, "but a better way I've found is the high-speed Danish cultivator. [His model is a Noble from Sac City, Iowa.] This row cultivator has narrow tines for shovels, and when pulled through the ground they shimmy and shake, avoiding buildups of plant debris and clumps of sod. I had no trouble even cultivating corn that I had planted in a field previously sown with orchard grass, which always leaves troublesome clumps of roots when you work it up."

The payoff? Very little erosion, low overhead, and satisfactory crops. "We don't get high yields," says Mundt. "We aren't interested in that. We're looking for quality. We're satisfied with 80 to 90 bushels of corn. We feed it to our milk cows and beef animals and believe they respond with better efficiency than if they were fed highly chemicalized, heat-dried corn. We don't even plant for high yields. I like a plant population of around 17,000 in 40-inch rows for corn."



The chisel and Danish cultivator are Mundt's alternatives for the moldboard on his highly erosive soil.



The Cole 510 system set for chisel plowing with four springs, center spring, and gauge wheels for category 0 and 1 three-point hitches. Cole Mfg. Co.

SOURCES OF CHISEL PLOWS/SUBSOILERS

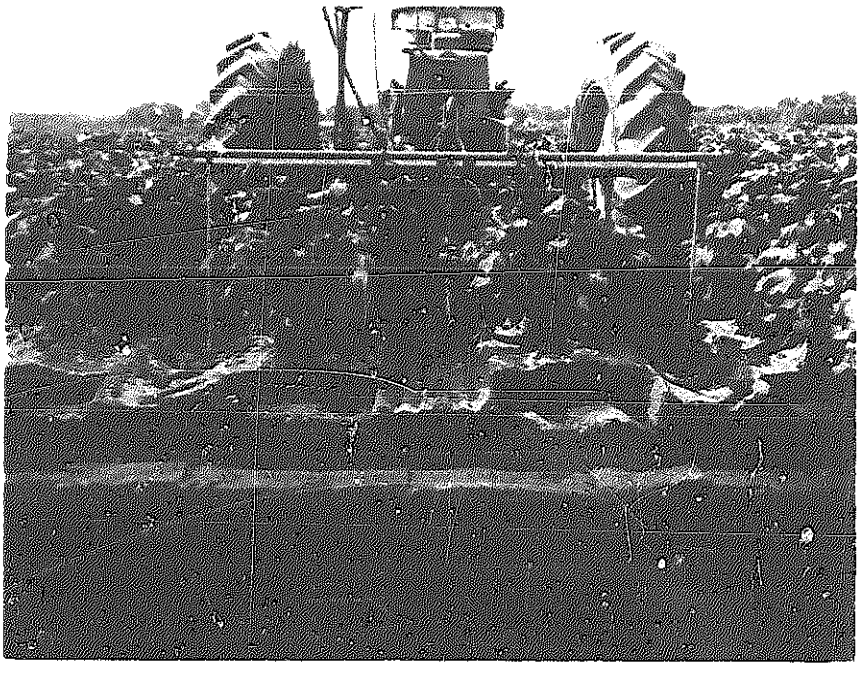
	CHISEL PLOWS (ass't. sizes)	GRAHAM PLOW	COMBINATION SUBSOILER/ CHISEL	SUBSOILER
BEAUVAIS & ROBIN, ETS.	X			
BOMFORD & EVERSHED LTD.			X	
J. I. CASE	X			
CECOCO				X
COLE MFG.	X *			
CORSICANA GRADER & MACHINE CO.				X
DELAPLACE, ETS.	X			
W. HERTECANT	X			
HUARD-UCF-SCM	X			X
INTERNATIONAL MODERN MACHINERY, INC.	X			
JEOFFROY MFG., INC.	X			
KMC (KELLEY MFG. CO.)	X			
KOEHN MFG. & DISTRIBUTING	X			
PLANET PLOWS, INC.		X		
ROYAL INDUSTRIES	X			
SEARS, ROEBUCK & CO.			X	
SOUTHEAST MFG. CO.				X
TAYLOR IMPLEMENT MFG. CO.	X			X
TRACTOR SUPPLY CO.	X			
UNITED FARM TOOLS	X			X
WIKOMI MFG. CO.			X	

* Available with planter attachment.

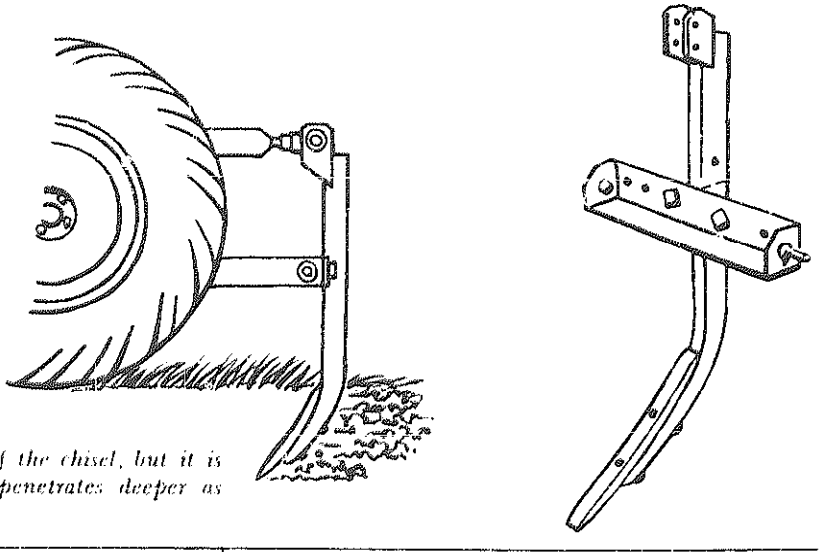
The Subsoiler

The chisel plow is not quite the same as a subsoil plow, sometimes called the deep chisel, or V-plow, though the actions of the two implements are now being combined into one machine. The subsoiler is a much heavier tool with narrow ripper blades that dig deeply into the soil to break up compacted layers for better drainage and root penetration.

The subsoil plow is a clear indication of the weakness of modern farming methods. It was designed to offset the negative effects of heavy



Years of moldboard plowing and use of heavy machinery have left this layer of hardpan which only the subsoil plow can penetrate. National Tillage Machinery Laboratory



The subsoiler assumes the shape of the chisel, but it is a much heavier-duty tool which penetrates deeper as well.

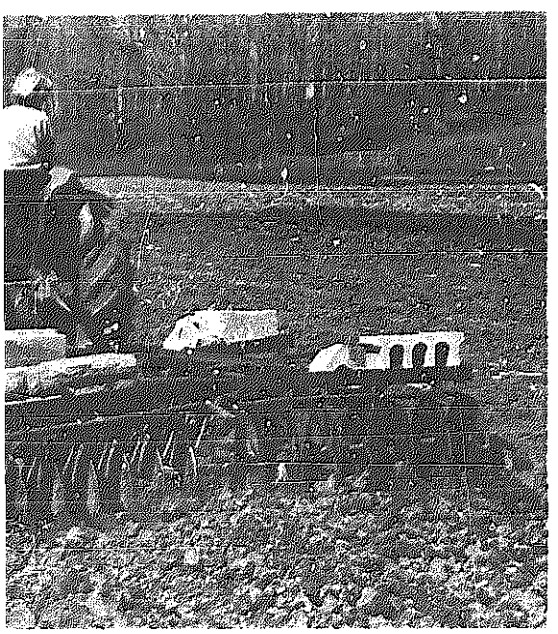
farm machinery and the discontinuation of rotations of alfalfa and sweet clover, whose roots formerly penetrated into and broke up hardpan, a slatelike layer of soil 6 to 8 inches beneath the surface, caused by compaction from heavy machinery.

A cure for hardpan, though only a temporary cure, the subsoiler is a deep-penetrating chiselike plow which requires a tremendous amount of power to pull. A small-scale operator shouldn't plan to pull more than one subsoiling plow with a small tractor, and only a larger small tractor at that.

The Disc Plow and Offset Disc

Disc plows are a third type of soil breaker or sodbuster. The original kind, which was fashionable in the middle 40s, consisted of from two to six large, heavy discs, which when pulled at a slant, turned the soil over somewhat like a moldboard plow. Though still used in some areas, they are being replaced by the offset disc,

The narrow sections of this spike-tooth harrow are light and easy to lift for inspection.





The narrow sections of this spike-tooth harrow are light and easy to lift for inspection.



The cement blocks increase cutting depth on this eight-foot, pull-type tandem disc harrow.

which resembles the conventional tandem disc, but is much heavier and is composed of only two gangs of discs positioned one behind the other at a bias to each other. (Tandem discs have four sets of gangs, two behind two.) At present, offset discs are very popular with farmers who have experienced erosion problems with the moldboard plow. What's more, the offset disc will incorporate rank, tall stands of green manure better than a chisel plow, and without plugging with crop residue.

The Disc Harrow

After a field is plowed and before it is planted, the soil has to be worked into a fine seedbed.

The standard tools for fining and leveling a good seedbed are the tandem disc and the spike-toothed harrow. The disc does the fining, and the harrow levels out the gouging marks of the disc. Hand tools in the garden do roughly the same operation when hoeing spaded soil into a finer texture and then smoothing it with a garden rake. Your hoe is the disc, your rake, the harrow.

If you can afford only one tool for this operation, make it a tandem-disc harrow. Old ones are common and often low-priced in the small 6-, 7-, or 8-foot widths. Yours should be wide enough to cover your tractor's tracks when pulling it. If the disc bearings are worn out, though, so that no amount of grease will get the blades rolling smoothly, look for another disc. There's usually one bearing for every two pairs of disc blades. Pump them full of grease and keep them that way.

Old disc blades are equipped with scrapers that are supposed to keep dirt from building up on them. On an old disc, they almost always will be bent out of position or loose. You may have to straighten and/or rebolt them. (Sometimes old bolts and burrs can be tightened, but more often they are rusted solid and have to be cut off and replaced.) Actually, if dirt is building up on your discs, nine times out of ten it means your clay soil is too wet for disking. When the soil is fit and the disc blades shiny—at least on their edges—dirt will seldom clog them.

Mounted discs, like mounted plows, are very nice for cultivating small plots and have the same advantages and disadvantages as the latter. Newer pull-type discs have rubber tires for transport and are raised or lowered to any desired depth by hydraulic pumps. If your tractor is equipped with hydraulic power, its potential usefulness is just about double that of a tractor not so equipped. If you are going to have to move your disc any distance on roads, you will need a fully mounted or rubber-tired disc.

Older discs can move from one field to another only on their disc blades, so the disc



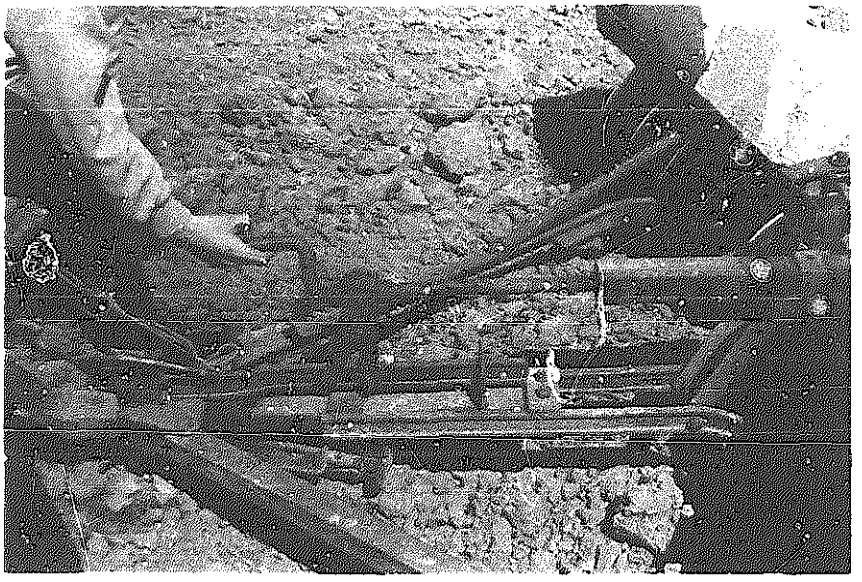
Location of grease zerk on disc. Note the correct positions of the scrapers against the disc blades.

The crank for adjusting the slant of the disc blades. Below, the sliding tongue assembly may be moved back and forth to slant or straighten the disc.

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just about ruin a field in a few
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ossible, pull a harrow behind
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cause if you are disking heavy
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you will find have levers that
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For deepest digging, you set
l. For dragging over ground
nes would clog the harrow, or
lanes and uncultivated fields,
rly horizontal. Someplace be-
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disc.
ne in sections usually about 4
ections attach to a front draw-
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taches to the back of the disc
er soil-working tool) by means
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he drawboard beam by chain-
gs. On old discs, these are often
out. Or they are replaced by



The crank for adjusting the slant of the disc blades. Below, the sliding tongue assembly may be moved back and forth to slant or straighten the disc.

gangs must be adjusted out of cutting position. A disc blade cuts and works the soil when it is slanted slightly sideways from the direction in which it is being pulled. The more slant, the deeper it digs. Moved out of slant completely, the blades roll along like wheels, barely cutting into the soil at all. On old discs, you can make the proper change from the tractor seat by means of a rope attached to a pin on the sliding disc tongue. With the disc hitched to the tractor, you pull the pin out of the slot it is resting in, drive forward, and the disc gangs straighten up. Release your pull on the rope, and the pin falls into another hole. To put the disc back in working position, pull the pin, back up slowly, and the sliding tongue assembly pushes the disc gangs back into slant position. Further adjustments can then be made by turning the crank above the disc tongue. The crank is intended to be turned from the tractor seat on most models, and it will turn much easier when the disc is actually moving.

No matter how much you fuss with your disc adjustment, getting the thing to leave a perfectly level swath is nearly impossible. If the front discs are cutting too deep in relation to the back, the center of the swath is too low, while the edges of the swath stay too high. If the back discs are cutting too deep in relation to the front, you have the opposite effect. The faster you go, the more this uneveness is accentuated. If you don't get your disc in good adjustment, you can just about ruin a field in a few years. The surface will look like the South Jersey surf.

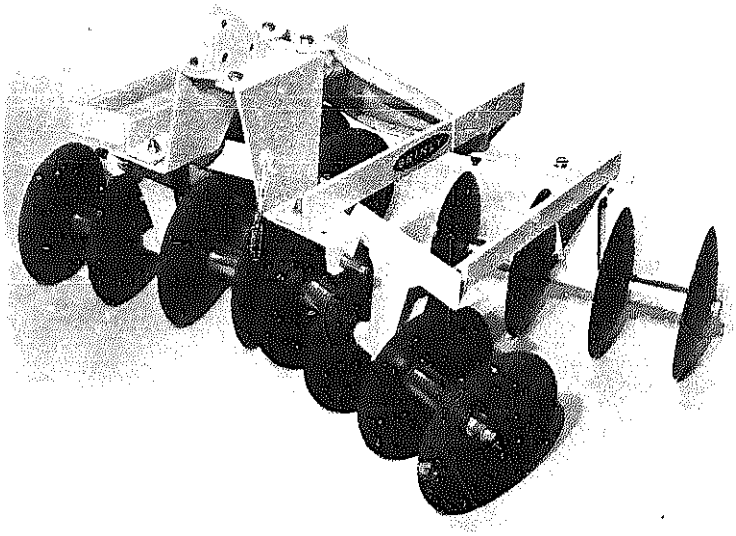
Whenever possible, pull a harrow behind your disc for the finest leveling. (We say "whenever possible" because if you are disking heavy cornstalks, or wheat or bean straw, you can't utilize the harrow behind the disc. It would clog up with the stalks.) Small, two-section harrows of 8 to 10 feet in width are fairly easy to find and can be purchased for anywhere from $25 to $125.

The harrows you will find have levers that adjust the teeth from nearly horizontal to nearly vertical positions. For deepest digging, you set the teeth vertical. For dragging over ground where plant residues would clog the harrow, or for moving over lanes and uncultivated fields, set the teeth nearly horizontal. Someplace between the extremes is usually best for leveling ground behind the disc.

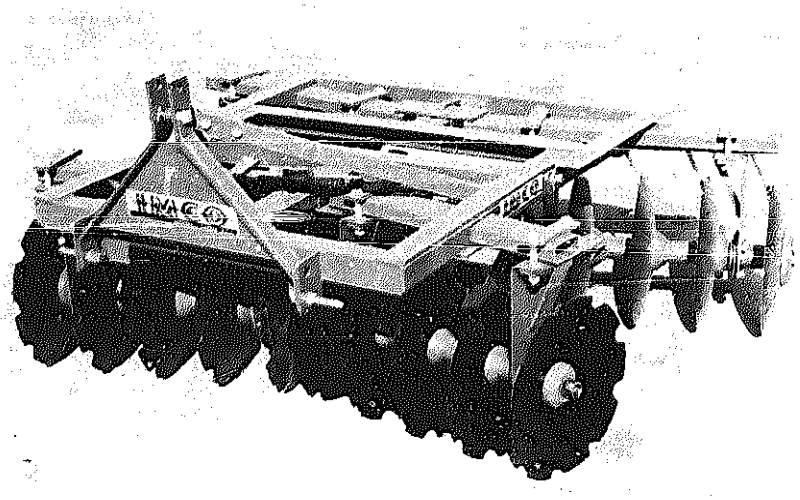
Harrows come in sections usually about 4 feet wide. The sections attach to a front drawboard beam which may be wood or steel. The beam, in turn, attaches to the back of the disc (or tractor or other soil-working tool) by means of a link-chain arrangement. The harrow sections connect to the drawboard beam by chain-link-type steel rings. On old discs, these are often missing or worn out. Or they are replaced by

baling wire. Sometimes the hooks on the harrow or the drawboard beam to which the rings attach are broken off. All that's fixable, but know what you're buying.

The levers are about the only other parts of harrows that wear out. The notch pin may be rusted tight, or the spring may be, or both; or the rod that connects the notch pin to the handle may be broken. Broken levers require welding. If you are really short of cash or time, you can just ignore broken levers if the teeth are already set about right. Yes, broken levers sell cheap.



The Brinly-Hardy Model DD-1000 tandem disc harrow is equipped with four gangs, each having four 11-inch, heat-treated, steel discs. Gangs may be set at angles of 10°, 15°, or 20°, or moved horizontally. Width of cut is approximately 52 inches. The heavy-duty frame is designed to hold concrete blocks for additional ballast. This implement is designed for 14 to 18 h.p. garden tractors with category 0 three-point hitch. Weight: 182 pounds.
Brinly-Hardy Co.



The IMCO Intermediate disc harrow is designed to be used as a medium-weight tandem harrow. It features a welded frame, gang adjustments of 5° to 20° with positive locking in position, 7¼- or 9-inch blade spacing, cutting widths of 5 feet 9 inches to 8 feet 11 inches.
Independent Mfg. Co.

Cultipacker

If clods are a problem in your spring-plowed soil, you may eventually want to add a cultimulcher or cultipacker to your repertoire of tillage tools. And, in time, a small chisel plow and/or field cultivator will certainly be in order. But with plow, disc, and harrow, you're on your way. You should be able to handle up to 40 acres of diversified cropland with a 35 h.p. tractor, a two-bottom plow, an 8-foot disc, and a 10-foot harrow.

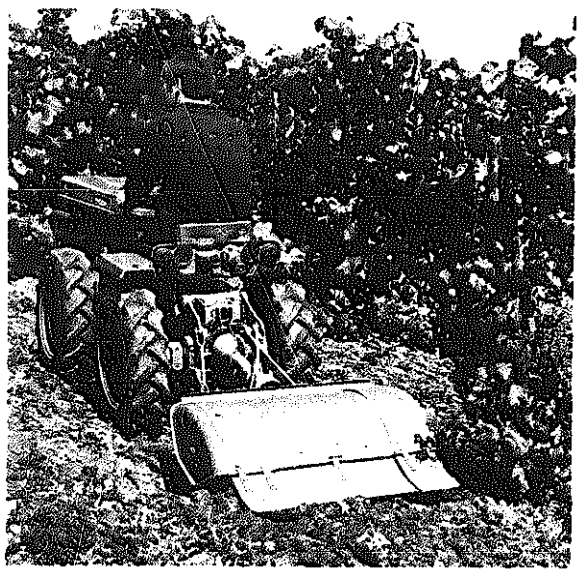
SOURCES OF HARROWS

	SPIKE-TOOTH HARROW	COIL-SPRING HARROW TINE	FLEXIBLE HARROW	SPRING-TOOTH HARROW	DISC HARROWS
AGM EQUIPMENTS	X				
BEAUVAIS & ROBIN ETS.	X		X		
BRINLY-HARDY CO.	X				X
BROWN MFG. CORP.					X
CECOCO	X				X
CENTRAL TRACTOR					X
EDWARDS EQUIPMENT CO.					X
FARNAM EQUIPMENT CO.			X		
FUERST BROS., INC.			X		
GHERARDI					X
W. HERTECANT	X				
HUARD					X
IMCO					X
INDUSTRIAS METALURGICAS					X
INTERNATIONAL MODERN MACHINERY, INC.					X
JOHN R. KOVAR MFG. CO., INC.	X	X	X	X	
MONTGOMERY WARD					X
NOBLE MFG. CO.	X	X	X		
PIERCE				X	X
SEARS, ROEBUCK & CO.					X
SOUTHEAST MFG. CO.	X				
SPEECO					X
TAYLOR IMPLEMENT MFG. CO.					X
TONUTTI S.P.A.	X				X
UNITED FARM TOOLS		X			
VASSAR CO.					X
WIKOMI					X

The Rotary Tiller

The rotary tiller can be used in place of a moldboard plow. Heavy ones for farm tractors and medium-sized ones for large, commercial, walking tractors are available, as well as the popular self-propelled garden tillers. The rotary tiller is probably the ideal tool for incorporating organic matter and avoiding soil compaction.

However, it is the nature of the tool that it can only move slowly across a field, and for that reason, it has not gained popularity on larger farms. When heavy stands of green manure have to be incorporated into the soil, the rotary tiller must usually be preceded by a stalk chopper or rotary mower to chop the plant material. Otherwise, rotary tiller tines will frequently entangle with crop residues.



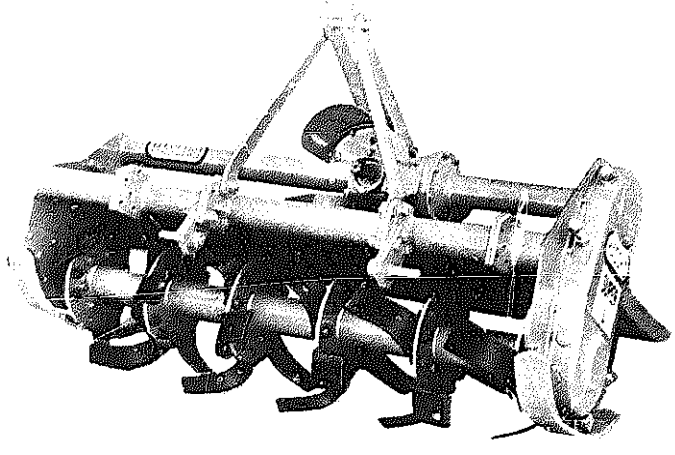
In action, a rotary tiller among the vineyards as pulled behind the Holder A-18 tractor.

Holder

THE HOWARD ROTAVATOR

by Thomas J. Ulick

The Howard Rotavator is a fine tilling tool available for the small- to medium-sized vegetable grower. It allows you to prepare a seedbed in conditions which would be impossible for other types of tractor-powered or horse-drawn equipment, provides an incomparable seedbed, aerates soil, incorporates crop residues, and so forth. It very well may be used for cultivating, bed forming, and other operations, and may be coupled with planters or drills for one-pass tillage and planting. I have found objections that rotavators require excessive amounts of tractor power unfounded. I operate an 80-inch rotavator with a 45 horsepower, Ford 3000 diesel tractor on about two gallons of diesel fuel per hour. I can easily cover one to one-and-one-half acres per hour, and by making two or three passes am able to work 12 to 14 inches deep under most conditions. Howard Rotavators are distributed by a worldwide network of dealerships, a list of which can be obtained by writing: Howard Rotavator Company, Harvard, IL 60033.



Visible on this rotary cultivator are the three attaching points of a three-point hitch, the rotovating tines, and the power-take-off connection for hitching to a tractor PTO shaft. This is the Ferrari Super L rotary tiller.

Ferrari International, Inc.

THE SPRING-TOOTHED HARROW

The spring-toothed harrow is used principally as a soil leveler behind a disc, though it digs more deeply than the spike-toothed harrow.

The spring-toothed harrow collects surface trash and plant material very easily and is therefore seldom usable in organic farming except after the moldboard plow.

HARROW IMPROVISATION

by Rob Johnston, Johnny's Selected Seeds

There is a tool often called a Scotch Harrow, a fencelike grid of chain, which is tractor-drawn to level a seedbed. Well, I'd wanted one for years but never felt we could afford it. Anyway, we now achieve just about the same effect by attaching a large old barn beam behind the disc harrow with a towing chain. The beam drags along behind the disc, leveling out high spots and filling in the ruts left at the edge of the harrow. If we need a really perfect seedbed for some delicate crop, we take time to go over the piece with a steel garden rake and have found it important to have one with an extra-long handle. This really gets it smooth and permits easy location of surface debris and stones.

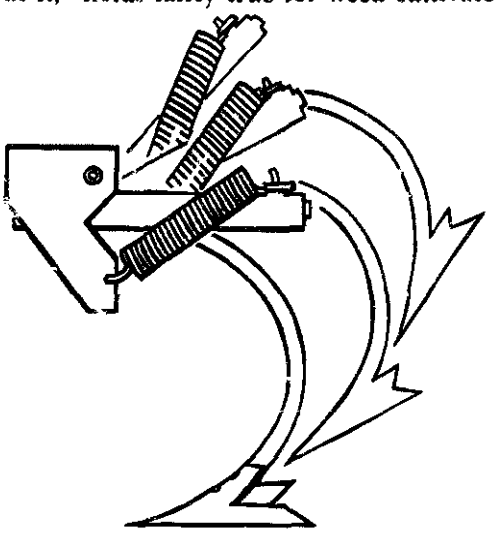
The Cultimulcher

The cultimulcher or pulvimulcher is a combination of spring-tooth harrow and cultipacker—a set of cultipacker wheels in front and rear, with harrow tines in the middle. It is used (if at all anymore) to put a smooth surface of fine soil on recently plowed ground to prevent moisture from escaping in a dry planting season.

WEED CONTROL TILLAGE

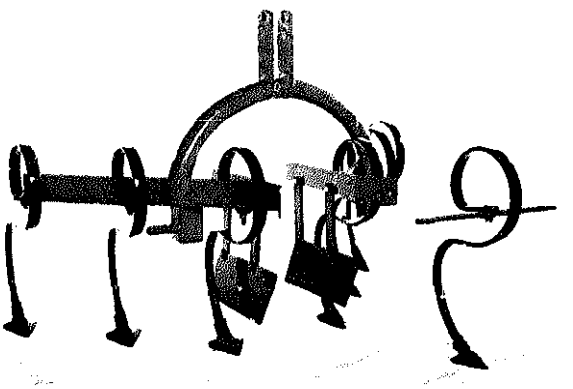
Cultivating Blades

The old saying, "There are as many opinions on a subject as there are people thinking about it," holds fairly true for weed cultivators.



The "spring" in the spring tooth protects the tool when it hits a hard object.

There seem to be as many different kinds as there have been farmers who like to tinker. Some blades are shovel-shaped, some spear-shaped, some almost identical to the teeth of a spring-tooth harrow, some little more than narrow steel bars. All have some kind of spring or give to them. Spring-trip shovels will snap back out of the ground if they hit a root or rock

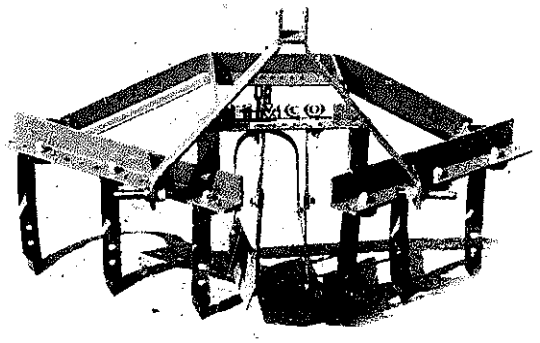


The Wikomi one-row Vibrating "S" Tine Cultivator with an optional one-row shield. The vibrating characteristic allows the share to vibrate strongly sideways to churn the soil. It provides proper tine spacing with lateral tine spacing adjustment for 20- to 40-inch row spacing.
Wikomi Mfg. Co.

that will not budge. The very narrow spring-tine cultivators, often called Danish tooth blades, vibrate and wiggle through the soil and seldom collect plant residue.

The rotary hoe is a special tool, consisting of several rows of pointed steel wheels, each about 10 inches in diameter. When pulled at a fairly rapid tractor speed, these wheels will dig out very small, germinating weed seeds without harming sprouted crop seeds if the latter are no more than an inch or two tall. The rotary hoe has become obsolete on farms where the use of herbicides predominates, but it is still an important tool on other farms, since the most important weed control is that obtained between the time a crop is planted and the time it is tall enough to cultivate with a regular shovel or tine weeder.

Rotary tillers convert to effective between-the-row cultivation, especially those with a faster gear than the one normally used for deep tilling. It should be set so it does not dig too deeply when cultivating weeds.



The IMCO one-row cultivator with reversible, heat-treated shovels. Heavy-duty spring tines and row shield are also available.
Independent Mfg. Co.

NORTH AMERICAN SOURCES OF CULTIVATORS

	CULTIVATORS	CULTIVATORS WITH VIBRATING TINES	DISC CULTIVATORS (ROLLING FENDERS)		ROTARY CULTIVATORS TILLAGE REPLACEMENT POINTS
ALLIED FARM EQUIPMENT	X	X	X	X	
BRINLY-HARDY CO., INC.	X*				
CENTRAL TRACTOR		X			
EMPIRE PLOW CO.					X
GANTT MFG.	X				
GILMORE-TATGE MFG. CO., INC. (ALLIED)			X		
GILSON BROS.			X		
IMCO (INDEPENDENT MFG. CO.)	X				
MONTGOMERY WARD		X*	X		
NOBLE CULTIVATORS, LTD.	X				
ROYAL INDUSTRIES	X	X	X		
SEARS, ROEBUCK & CO.		X	X		
SPEECO (SPECIAL PRODUCTS CO.)	X	X			

* Models with planter bar hookup.

NORTH AMERICAN SOURCES OF CULTIVATORS

	CULTIVATORS	CULTIVATORS WITH VIBRATING TINES	DISC CULTIVATORS (ROLLING FENDERS)	ROTARY CULTIVATORS TILLAGE REPLACEMENT POINTS
TAYLOR IMPLEMENT MFG. CO. (ALLIED)	X			
TRACTOR SUPPLY CO.		X		
UTILITY TOOL & BODY CO.			X	
WIKOMI MFG. CO.	X	X	X	

INTERNATIONAL SOURCES OF CULTIVATORS

	CULTIVATORS	CULTIVATORS WITH VIBRATING TINES	DISC CULTIVATORS (ROLLING FENDERS)	ROTARY CULTIVATORS
ACM EQUIPMENTS	X	X		
AGRATOR INDUSTRIAL, S.L.				X
BEAUVAIS & ROBIN, ETS.	X	X		
CECOCO				X
DELAPLACE, ETS.	X			
GHERARDI S.P.A.	X			X
W. HERTECANT	X			
HUARD-UCF-SCM	X			X
INDUSTRIA METALURGICAS APOLO S.A.	X			
JUMIL, JUSTINO DE MORAES, IRMAOS S.A.	X •			
KUHN S.A.				X
PIERCE OF WEXFORD		X		
SCHANZLIN MASCHINENFABRIK GMBH				X
TONUTTI S.P.A.	X			
YANMAR DIESEL ENGINE CO.				X

• Models with attached fertilizer spreader.

-3- The Continuing Role of Draft Animals

FARMING WITH HORSES

by Wendell Berry

A team of horses, living off the hay and grain it helps to produce, is an embodiment of the life of the farm—which, under good care, is perpetually self-renewing. A team is therefore not only a much cheaper source of power than a tractor, but it is also a source that in the long run will be much more dependable. And whereas the wastes from a tractor's engine only pollute the air, a horse's bodily wastes will enrich the ground from which he feeds, thus significantly reducing the farmer's dependence on the fertilizer companies.

And horses, unlike tractors, can reproduce themselves. Many small farmers will find it possible to raise a pair of colts a year from a team of work mares. If the quality of the colts is good, and if the horse market stays favorable, the work team may earn considerably more than its feed bill, and thus provide the farmer with a year of free labor, plus some profit.

In the work itself, horses have certain advantages over tractors. They can be used safely on steep ground, where a tractor would be either dangerous or useless. A horse farmer can get into his fields



On the decline: as power equipment like this one-row corn harvester took hold, the significance of the draft horse began to fade. American Society of Agricultural Engineers

more quickly after rain than can a tractor farmer. And horses do not pack the ground as much as tractors. It is generally acknowledged among the tobacco growers in my area of Kentucky that the work of horse-drawn cultivating plows has never been equalled by any tractor.

Beyond these practicalities, there is the satisfaction that one gets from working a good team. A tractor may be handy, always ready to use, untiring, enormously powerful; but it is not alive, and that

is a great difference. To work all day with a well-broke and willing team is a pleasure as well as a job; it is a cooperative venture, a sort of social event. And when the day's work is finished, to stable the team and water and feed them well, or to turn them out onto good pasture, is a comfort and a fulfillment. Between a farmer and a team there exists a sort of fellow feeling that is impossible between a farmer and a tractor, and for me that rates as a considerable advantage.

Another thing I like about working with horses is their quietness. When you work with a tractor you hear nothing but the tractor; it is a kind of isolation. With the engine roaring in your ears all day, you lose awareness of the other life that is going on around you. With horses, unless you are using some noisy implement like a mowing machine, you hear the wind blowing and the birds singing and all the rest of the stirrings and goings-on of the countryside.

And so there is a good deal that can be said in favor of farming with horses. There are, in fact, a few widely scattered farmers who still do farm exclusively with horses. There are many more who keep a team or two for part-time use. And of course there are the Amish, for whom farming with horses is a community ideal and a way of life. Nevertheless, it would be irresponsible simply to recommend to anybody who owns a farm that he should sell his tractor and buy a team. There are difficulties



The draft horse farmer should be prepared to work a little harder physically than his mechanized neighbor. Here a team of blacks gets started on a morning's disking.

in the way; it is important that I should now mention them, and that interested readers should consider them with great care.

1. In many parts of the country a good team is difficult to find. And though a good team is less expensive than a good tractor, it will still be costly. At present the price of horses is high, and rising.
2. Most horse-drawn equipment has been out of production for many years. Some tractor equipment, of course, is fairly easily convertible for use with horses.
3. Horses are not standard. No two are exactly alike in looks, size, conformation, or disposition. It is therefore extremely unwise for an inexperienced person to attempt to buy a team on his own. I have said that a good team is a source of pleasure. It is now time to say that a bad one is a curse, a nuisance, a liability—sometimes a danger. Some horsemen will take pride in selling good stock and in satisfying their customers. Some will sell poor stock with extravagant praise.
4. Most important: It is not easy to work with and care for a team. It cannot be learned easily or quickly. A person who can drive a car can probably teach himself to drive a tractor in a short while. To learn to drive a team well, you need a teacher, and you need experience. An inex-

perienced teamster can easily injure or kill his team and can easily get injured or killed himself.

5. Obviously, then, a person inexperienced with horses who wants to farm with them is much in need of the advice and instruction of an experienced teamster whose intelligence and judgment can be trusted. And this brings us to the final difficulty: such people are getting scarce. The last generations that grew up working horses are dying out, and their knowledge is dying with them.

Fortunately, there are some experienced horsemen scattered over the country who have had these problems on their minds. And because of their efforts there begins to be some promise of help for the would-be or the novice teamster.

First, I want to mention, and recommend, *The Draft Horse Journal* (Route 3, Waverly, IA 50677), edited by Maurice and Jeannine Telleen. This magazine is an assembly point for all sorts of information about sales, breeders and dealers, suppliers of equipment, and other items of interest. There are articles on the history, breeding, and care of draft horses. And in the short time that I have been a subscriber, there has been an increasing number of articles on the use of horses for farm work. Anyone interested in farming with horses would find this magazine both a pleasure and a valuable investment.

In the Summer 1973 issue of the *Journal*, I was much interested to see an article which announced the first session of a Teamster's School to be held at Indian Summer Farm in Cabot, Vermont. According to the article, Ted Bermingham had undertaken to set up the school on his farm with the hope of preserving and passing on the knowledge and skill of "the last full generation of working teamsters." For this purpose Mr. Bermingham had rounded up a faculty of experienced horsemen to teach the disciplines of farming and logging with horses. Tuition was $150. This paid for all instruction, stall and board for a horse or team (if any), supper on Sunday night, and three meals a day, Monday through Thursday. Daytime instruction involved working at the chores of farming and logging. Study of the various tools and techniques always took place amid the practicalities of actual use. Students drove their own horses or horses furnished by the school under close supervision of the teachers. They also took part in the necessary stable work. The night sessions consisted of talks on such topics as horse husbandry, logging techniques, breeding, equine genetics, veterinary medicine, horse trading, and shoeing.

Mr. Bermingham and his staff are well aware, of course, that the teamster's art is complex and dependent upon experience, and that no novice could hope to become proficient at it in a few days. The school is meant to offer as full an introduction as possible to skills that the beginner can then practice on his own. There is no doubt that a few hours of work with an experienced teacher can save many hours of expensive and dangerous self-instruction by the method of trial and error. The students I talked to all believed that the school had been thoroughly worthwhile. So did their teachers—and so did I.

I hope that such schools will soon be undertaken in other parts of the country. They would be good for the draft horse business, and they would be good for farming.

The school was sponsored by the Draft Horse Institute, established in 1972 by Ted Bermingham, to collect and maintain the working knowledge of farming and using draft horses before it was lost. For information on the future sessions planned for coming seasons, you can write to Mr. Bermingham at Indian Summer Farm, Cabot, VT 05647.

POWER FOR FIELD WORK

by Joseph K. Campbell

What are the sources of power for field work in the world? According to the FAO (Food and Agriculture Organization of the United Nations), there are approximately 16.9 million agricultural tractors and 267.4 million horses, mules, asses, water buffalo, and camels in the world. Of course many of these

animals are used for transportation, but a large proportion of them are used as draft animals. There are also estimated to be 1,200,000,000 cattle in the world. Most of the cattle are used for meat and milk, with only a few used as draft cows or draft oxen. The distribution of the animals is shown in Table I.

Table I DRAFT ANIMALS AND AGRICULTURAL TRACTORS

(in thousands) [a]

	CATTLE [b]	WATER BUFFALO	HORSES	MULES	ASSES	CAMELS	FARM TRACTORS [c]
NORTH & CENTRAL AMERICA	193,407	7	17,339	2,967	3,367	——	5,146.5
SOUTH AMERICA	212,444	166	16,837	5,934	5,410	——	525.4
AFRICA	151,396	2,280	3,567	2,140	11,235	9,624	379.5
EUROPE	135,363	433	6,115	844	1,584	——	7,000.6
USSR	109,122	427	6,749	2	501	253	2,267.
ASIA	356,439	128,455	14,085	2,267	20,000	4,233	1,137.5
OCEANIA	43,072	——	580	——	5	2	437.2
WORLD	1,201,243	131,769	65,272	14,154	42,101	14,112	16,893.7

a. Based on tables 102, 103, & 125 of the 1975 FAO *Production Yearbook*
b. Primarily for meat and milk
c. Sum of tracklaying and four-wheel farm tractors over eight developed horsepower and/or weighing more than 850 kilograms

What are the horsepower ratings of these various sources of agricultural power? Before answering this question, let's review the relationship of force, work, power, and energy.



The original source of the term "horsepower." The Implement Age, 1894

A force can be visualized as a pull or push which tends to move the subject being pulled or pushed. For example, a force of 250 kilograms may be required to pull a plow through the soil. In agriculture we refer to this force as draft and animals which pull loads as draft animals. Whether the plow is pulled a meter or a kilometer, the draft in this example remains two hundred and fifty kilograms.

The term work includes the dimension of distance. Work equals force times distance. The metric unit of work is the kilogram-meter. The English unit is the foot-pound. Note that work does not state the amount of time required to do a job. For example, to plow a hectare of land requires the same amount of work whether the job is done in twelve hours with a garden tractor or an hour with a large farm tractor. However, the power requirements will be very different.

Power is the rate of doing work. The faster the work is to be completed, the greater the power required. The unit of power in the English system is the horsepower. In the metric system power is measured by the kilowatt and metric horsepower. Horsepower is actually the rate at which a large draft horse can work. When the eighteenth century Scotsman, James Watt, was designing steam engines, he was faced with prospective customers insisting upon knowing the number of horses which could be replaced by a steam engine. So Watt experimented with some draft horses and determined that a horse exerting a constant 150-pound pull walked at two and one-half miles per hour. Watt called this amount of power one horsepower.

MAN AS A POWER SOURCE

From the food he consumes, a man develops horsepower, but only one-tenth is available for sustained useful work. The remainder is expended in life functions of the body. Thus, as an engine converting fuel to mechanical energy, we are about 20 percent efficient. Our muscles do provide some work overload reserve. For bursts of energy of less than a second, up to six horsepower may be expended. A rule of thumb for useful power for periods of four minutes to eight hours is mathematically expressed by:

$$HP = 0.35 - 0.092 \log t$$ (t is in minutes.)

For example, a man can put out one-eighth horsepower over four hours, but if he is putting out one-fourth horsepower he will last only about 12 minutes. The above rule of thumb assumes a 35-year-old male European laborer. A 20-year-old male will be able to generate 15 percent more useful work while a 60-year-old will generate about 20 percent less.

Man cannot compete successfully with engines or dumb animals as a source of power for constant-load repetitive jobs such as pumping water for irrigation. His low power output places him at a disadvantage. However, man has a unique brain and is well adapted for jobs with a low power requirement but demanding decision-making and dexterity of hand. For example, transplanting rice demands thought as well as dexterity—does the plant have sufficient roots? Is the spacing correct?

DRAFT ANIMALS

Oxen, water buffalo, horses, and mules are the primary draft animals. Camels and asses (donkeys) are more typically used as pack animals although they are used for pulling carts and tillage tools in some countries. Viewing the draft animal as a machine, we see that it can feed itself, maintain itself, be programmed for automatic control, and reproduce itself—four functions a tractor cannot perform. As a mechanism, the animal is a jointed framework held together with ligaments and muscles. The engine consists of the digestive organs while the products of combustion are removed by the excretory system. The brain and nervous system provide a control system with a memory bank, logic circuits, and feedback loops. Joints and moving parts have a sealed lubrication system. Protecting the mechanism is a covering of hide which is resistant to damage and self-healing as far as minor dents and scratches are concerned.

Unlike the farm tractor, however, draft animals can be purchased in a very limited range of horsepower, cannot be worked continuously, and continue to burn fuel when not working.

An FAO publication states that when used as draft animals, bovines have an energy efficiency of 9 to 10 percent and members of the horse family 10 to 12 percent. However, other experts state that horses have an efficiency of about 20 percent. The difference between investigators is probably due to the breed, type of feed, and whether the work was done by the test animals on treadmills or draft devices. As a reference point, the efficiency of energy conversion for gasoline and diesel engines is 20 to 35 percent.

POWER SUPPLIED BY DRAFT ANIMALS

ANIMAL	AVG. WEIGHT KG	APPROX-IMATE DRAFT KG	AVERAGE SPEED OF WORK KM/HR	POWER DEVL. H.P.
LIGHT HORSES	400-700	60-80	3.6	1.0
OXEN	500-900	60-80	2.0-3.0	.75
WATER BUFFALOS	400-900	50-80	2.9-3.2	.75
COWS	400-600	50-60	2.5	.45
MULES	350-500	50-60	3.2-3.6	.70
ASSES	200-300	30-40	2.5	.35
CAMELS	450-550	40-50	4.0	.67

Adapted from FAO Ag. Devl. Paper No. 91.

In general, a draft animal can pull approximately one-tenth of its weight. Horses provide a higher output than the other animals in relation to body weight. Just as an internal combustion engine requires high-quality fuel to perform well, an animal requires a sufficient amount of high-quality fuel to develop maximum power. The availability of fuel (feed) affects the choice of draft animal. Oxen, water buffalo, and camels can be thought of as low-octane engines able to perform on low-quality feed such as coarse forages while the horse can put out more power but demands higher-energy fuel in the form of grain. Asses and mules are intermediate on this fuel scale.

Like man, animals can, during a short period of overload, develop large bursts of power. A good pair of draft horses have been able to develop 20 to 25 horsepower for ten seconds while a yoke of good oxen have developed 20 to 30 horsepower over a distance of 100 yards. Compared to the power which a draft animal can produce over a six- to ten-hour day, the maximum power which can be maintained for five to 30 minutes is four times as great while the maximum power which can be exerted over a few seconds is 25 times as great.

Animals must receive periods of rest. In general, horses and mules can be worked eight to ten hours daily but should be given a break at noon. Adult oxen can be worked for six to eight hours although younger oxen or poorly fed animals may only work four hours daily. Water buffalos are worked approximately six hours per day. It is impossible to provide precise data for draft animals since performance depends upon an animal's individual characteristics such as breed, weight, sex, age, health, training, and feed quality.

Harness is the means by which the animal's effort is applied to the load. Poorly designed and ill-fitting harness not only reduces the available power but also causes the animal to suffer. When one animal cannot provide sufficient draft or power, a number of animals can be harnessed together as a team, but at a loss in individual efficiency. In general, if animals of equal strength are harnessed together as a team, the draft of a single animal working alone should be multiplied by 1.9 for two animals; by 2.5 for three; by 3.1 for four; by 3.5 for five, and by 3.8 for six. If six oxen are yoked together, the resultant draft will be double that of two oxen.

THOUGHTS OF A DESIGNER OF ANIMAL-DRAWN EQUIPMENT

by Jean Nolle

For several years, people have asked me: "Why do you invent new animal-drawn machinery when draft animals have almost disappeared? Why do you persevere in this misguided way when everything proves now that mankind is setting up his future on a highly developed technological base? What are your reasons for dedicating your life to the rescue of draft animals?"

Before I try to answer, I must first correct a mistake in the question. I do not dedicate my life to the rescue of draft animals, but to the development of the forgotten farmers.

That being said, I can explain that for 27 years, I have been involved in agriculture in almost all tropical countries. Since I was working alone, perhaps the modesty of my labor kept me safe from the noise around and allowed me to continue the same point of view for so long a time. Many developments have altered specific actions in machinery design, but there has been no deviation in my intentions.

I developed a new technology in matters of animal-drawn machinery for small agriculture for several reasons. The first was opportunity. In 1950 in Senegal, there were two large farms of 5,000 hectares each. They were set up to grow peanuts, and equipped with heavy-duty tractors and sophisticated implements. Both went bankrupt in 1954. The reasons were said to be climate, soil, plants, and human population.

Both of them were obliged to change their ways. At the first one, located in the Casamance region of south Senegal, the tse-tse flies prevented the use of draft animals so the farm continued its use of heavy-duty tractors, with the farmers using traditional hand tools.

The second, named Secteur de Modernization Agricole (S.M.A.) was located in central Senegal where tse-tse flies were unknown. As this farm was a state enterprise, the government decided to improve the animal-drawn machinery there. I was engaged by the S.M.A. from 1954 to 1958 with *carte blanche* to conceive, realize, experiment with and develop various animal-drawn machines.

I had to discover a formula that made possible the farmers' evolution from extensive methods to intensive ones. I had to find a solution to the width, the length, and the solidity of my future machines. I had to invent some ways to stimulate the curiosity of the farmers in order to make them understand without any teacher the laws of the interdependence between various farming operations.

It was quite a challenge to discover a single formula that could answer these diverse questions. However, it exists. Its name: polyvalence, or versatility.

To be successful in the tropics or with small-scale agriculture anywhere, a machine must be versatile. This adaptability is the strength of tractors with three-point hitches, and it applies to animal-drawn implements as well. In the design of agricultural machines, the main aspects of this versatility are the ability to adjust track width and the ability of the chassis to accept numerous implements. Next in importance is the means used to change the track and to attach the implements.

Single-purpose machines have their own chassis. Multipurpose machines, on the other hand, use the same chassis for many tasks. Of course, if the price of a multipurpose chassis is higher than that of several single-purpose chassis, the purpose is defeated. Likewise, if the device required to fit the various implements on the multipurpose machine is too complicated, farmers will not change them and the machine will be single-purpose anyway.

To meet these requirements, I had to design several chassis to meet the needs of farms ranging in size from two to 20 hectares. While the dimensions of the chassis varied, the hitching device was to be standard. At first, nuts and bolts seemed the simplest solution, but bolts require fixed holes in both the chassis and the tools, thereby limiting their versatility and ultimately weakening the chassis. Nuts and bolts are also subject to rust, and eventually require a hammer and chisel to remove them. In reality, the farmer rarely does this, and the machine becomes single-purpose once again.

My solution was to design a special type of U-shaped clamp. Each branch of the clamp is dug with a square hole, and the bottom of the clamp has an eye screw. Square holes are very helpful as they permit tools to be attached to any part of the chassis without drilling holes in the chassis.

NOLLE'S EQUIPMENT

Described below are some examples of Jean Nolle's ingenuity at designing multipurpose agricultural equipment for widely varying soil and cropping conditions. The emphasis on economy, ease of operation and maintenance, and versatility is consistent. Additional information on Nolle's machines may be obtained from the manufacturer, Mouzon S.A., 60250 Mouy, France.

Polycultor

The *polycultor* is an ox-drawn chassis adaptable to a wide range of cultivation implements. Designed by Nolle especially for farmers who need a small transport vehicle as well as a universal tool carrier, the polycultor features a hand lever for raising the implements and two handles on the toolbar for steering. The lift is connected to the toolbar by a chain for easy depth adjustment.



The Polycultor prepared for hoeing cotton in Uganda.
Jean Nolle

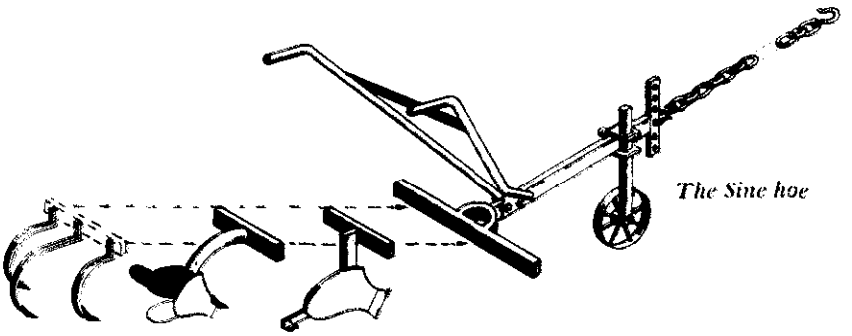
The toolbar is designed to carry from six to 12 cultivator tines. It can carry one or two ridgers, three markers for planting peanuts, a peanut lifter, and a grain drill. The single-bottom plow attaches directly to the axle with a stirrup clamp. Since it is fitted alongside the right wheel, the plow has its own lift. Uniform furrow width is obtained by the right wheel following the previous furrow. The farmer is seated in the middle of the chassis, beside the plow.

Another option is a 500-liter water drum, put in the same place the cart would normally be. Still another is a small mower, driven by the right wheel. The mower is mounted on the side of the platform cart, exactly in its pivot, so that it can be lifted for transport.

One of the chief obstacles preventing more widespread use of green manuring practices in Senegal and elsewhere in Africa is that the traditional moldboard plow with oxen is so difficult to keep in the ground with some of the newer, higher cover crops like sorghum. The stability and weight of the polycultor makes this much less difficult. The long stems are bent forward by the axle, so it is easier for the plow to cover them with earth.

Sine Hoe

Nolle's *polyculteur sine* (hoe) is built with a front bar, a rear bar, and a stirrup in between. This arrangement makes it possible to use the sine as a cultivator, with one short tine on the longitudinal toolbar and two short tines on the rear bar. For use as a hoe, three tines are attached to the rear bar, one long tine is placed in the middle, and two short tines are attached on the sides. The middle hoe is equipped with



The Sine hoe



The Sine as a cultivator in Vietnam.
Jean Nolle

a duck foot sweep, and the sides with left- and right-hand side shovels.

The rear bar can be adapted to carry a furrow plow, a ridger, and a rigid tooth harrow. Disc and spring-tooth harrows can also be attached.

The width and length of the sine can be modified by means of clamp-on extensions, thereby making it possible to use the tool with two wheels or two skids, with one or two ridgers, with five tines instead of three, and other options. All in all, the sine is a fine example of a machine that is readily adaptable to the job at hand and the strength of the animals.

Saloum

Ranking in size somewhere between the sine and the polycultor, the *saloum* was designed for areas with soils too hard for the lighter sine to penetrate. The square chassis and two forward wheels make it possible to load the saloum with a bag of sand to achieve greater weight for plowing or cultivating in clay soils. The machine was also valuable for harvesting peanuts in heavy soils.



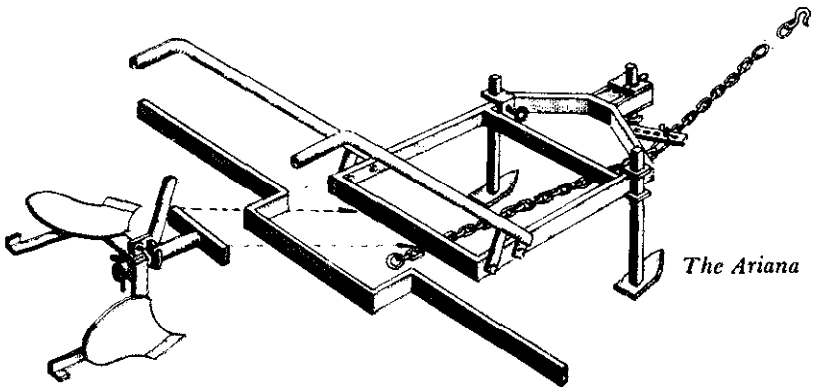
The Saloum
Jean Nolle

But the saloum was not without its disadvantages. With the two front wheels, it was almost impossible to steer effectively for hoeing. Since the wheels were not adjustable in height, it was also impossible to plow. Nor was it possible to adjust the width of the track.

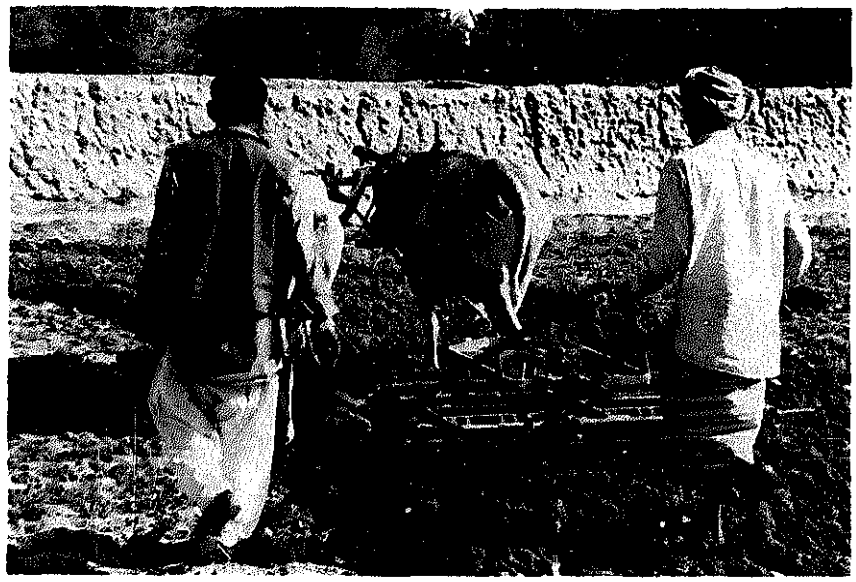
For these reasons, Nolle abandoned the saloum and replaced it with the ariana.

Ariana

The *ariana* belongs to what Jean Nolle terms his second generation of animal-drawn equipment. First conceived in Afghanistan in 1961, the ariana was Nolle's answer to applying the principles behind the sine and saloum to a region in which ridge cultivation (as opposed to flat cultivation) and irrigation prevailed. What was required was a reversible plow that would place the final furrow alongside the field rather than in it. The ridge cultivation also required more clearance under the chassis.



The Ariana

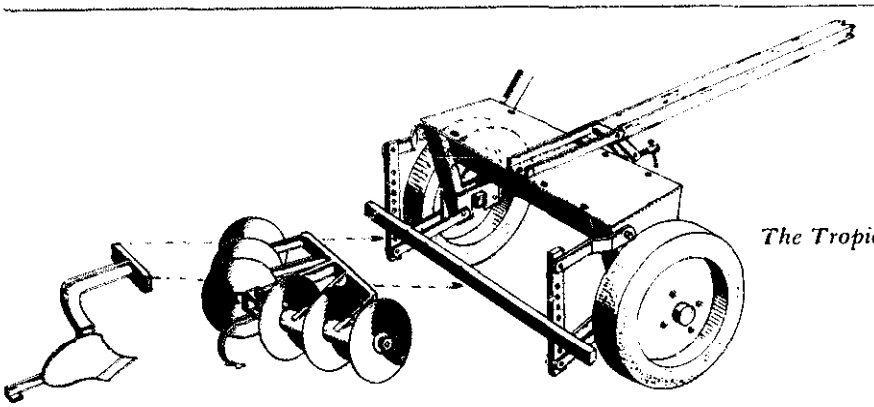


The Ariana preparing a seedbed with a cambridge roller and a spring-tooth harrow.
Jean Nolle

On Nolle's ariana, the two wheels for plowing are attached with clamps to the upright bars. Track width is adjustable from 30 to 70 centimeters. Besides the furrow plow and the reversible plow, the machine can be adapted with implements for ridging, cultivating, planting, fertilizing and peanut harvesting. For hoeing and all conventional cultivation work, the two wheels are replaced by a single wheel in the front center.

Tropicultor

Like Nolle's polycultor, the *tropicultor* is essentially a cart that is easily converted into a



The Tropicultor



The Tropicultor plowing in Uganda.
Jean Nolle

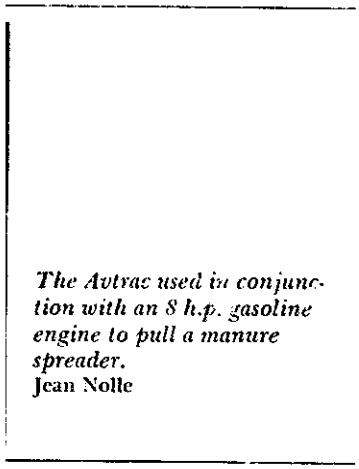
multipurpose tool carrier. Unlike its predecessor, however, the tropicultor is adjustable for rows of varying width, and its chassis is made of two steel pipes making it high enough for use above growing crops.

The angle of penetration of the implements is controlled by an adjustment of the shaft. The ability to lock the toolbar in the low working position represents a real breakthough in the design of multipurpose tool carriers of this sort. It frees the operator from having to constantly lean down on the handles and devise crude weighting schemes for the cart. With a track width that can be adjusted from 60 to 160 centimeters, and a ground clearance of 65 centimeters, the tropicultor can work in almost any soil and cropping conditions. Like Nolle's other machines, the tropicultor offers various extensions and adaptors that permit it to function as a grain drill, disc harrow, mower, reversible plow, planter, and cultivator. All attachments are easily fastened to the toolbar with standard clamps and pins.

All told, the tropicultor will accept 24 different implements that make possible over 30 uses on the small farm. Such versatility greatly enhances the independence of the farmer using the device.

Avtrac

The *avtrac* was invented in 1961 by Jean Nolle in response to a request from the French Ministry of Agriculture to design an improved horse-drawn tool carrier similar to those he had introduced in Senegal. At that time there were a million-and-a-half draft horses in use in France, and the avtrac was essentially an attempt to design three-point hitch implements for draft



The Avtrac used in conjunction with an 8 h.p. gasoline engine to pull a manure spreader.
Jean Nolle

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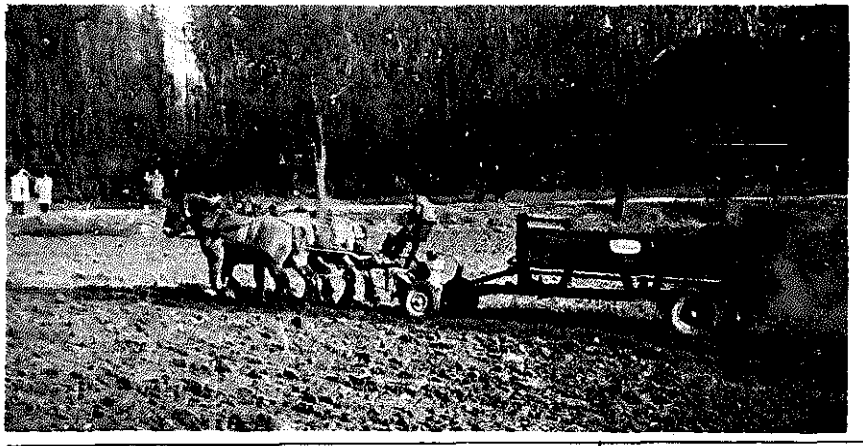
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The Avtrac used in conjunction with an 8 h.p. gasoline engine to pull a manure spreader.
Jean Nolle

animals similar to those used with tractor-drawn equipment. There was no one making horse-drawn equipment in France at the time, and a serious shortage prevailed.

The frame of the avtrac consists of a wide transverse pipe, in the middle of which is fitted the support for the shaft. The machine can be pulled by one, two, or three animals, and the equipment used is the equivalent of that designed for 25 h.p. tractors. Each wheel support has a rear-mounted swinging drawbar to receive a standard toolbar or other implements. The third point is in the middle of the chassis.

For pulling a trailer there's a hook mounted on the toolbar. For the mower, manure spreader, and other powered implements, an 8 h.p. engine with PTO is mounted between the wheels.

Kanol

In the early 1970s, Nolle was called upon to develop animal-drawn implements for use in Latin America. Finding that his sine and ariana tools were often unsuited to the hard volcanic clays there, Nolle worked out a simplified version of his tropicultor that used hooks to attach the implements rather than clamps.

The main frame of the *kanol* consists of a shaft connected to a device that contains two levers—one for adjusting the angle of penetration into the earth and another to control balance. Implements are detached by simply lifting a hook.

The kanol carries two categories of tools: narrow tools that do not require wheels (one-furrow plow, subsoiler, peanut lifter, cultivator, ridger, etc.), and wider implements equipped with two wheels for stability (those used in conjunction with 150- or 170-centimeter toolbars and transport uses).

Latin American farmers experienced with the older Asian-type plows were quick to accept the kanol. Those already using a sine or ariana needed only to purchase the main kanol support and toolbar; all the attachments were interchangeable. With the addition of the hooks, it became even easier to change implements than with clamps.

THE EFFICIENT USE OF ANIMAL POWER

by Wayne Dinsmore

Editor's note: This material is excerpted from a paper presented at the annual meeting of the American Society of Agricultural Engineers, December 27, 1921, and published in the February 1922 issue of *Agricultural Engineering*. The information is still valid for small farmers today.

It has been found possible to drive teams 20 miles per day in a ten-hour day on various farm implements and to maintain this rate week after week. This allows two hours for driving to and from fields,

hitching and unhitching, turning at ends, and occasional examination of collars. It requires that teams shall actually be in motion on productive work eight hours per day at an average speed of two and one-half miles per hour. When fresh, horses will exceed this; when weary, they will not equal it, but it is a practical standard, attained where sufficient horses or mules are used to permit steady driving, without stops to rest animals. Whenever teams require stops for rest, not enough power is being used. Put on another horse or a pair, or more if necessary, but add enough so that you can turn 20 miles of soil per day and not overdo the teams. The number of horses needed will depend on the hardness of the ground, the depth to which implements are cutting, the weather, and the age, size, and condition of the work animals used, so that each man must use "horse sense" and gauge his teams according to power needed.

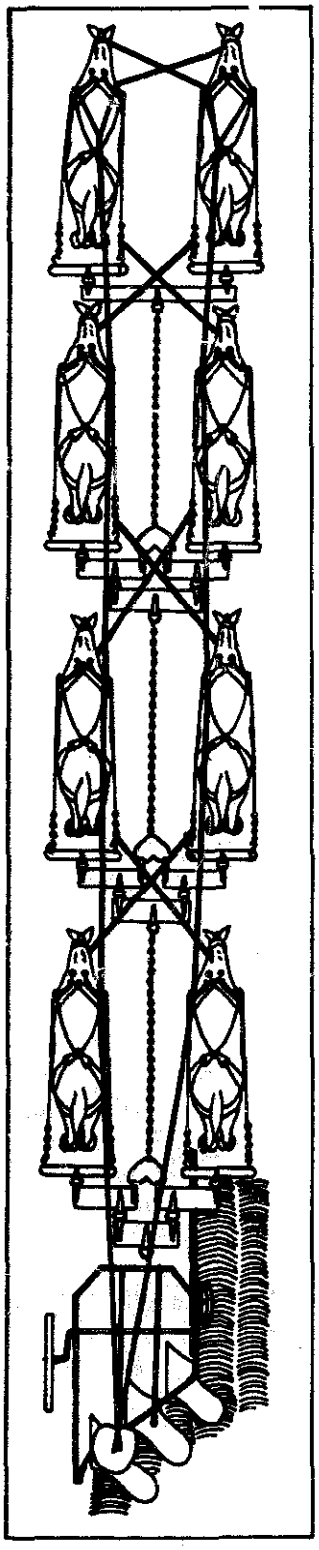
Twenty miles of productive work daily means 5.6 acres plowed with two bottom gangs, 14-inch plows; 24 acres double disked with ten-foot discs and trailer attachment; 70 acres harrowed with six-section harrows (five-foot sections); and as these soil preparation tasks are the ones requiring the most time, they also offer the greatest opportunity for cutting costs by increasing work done per day.

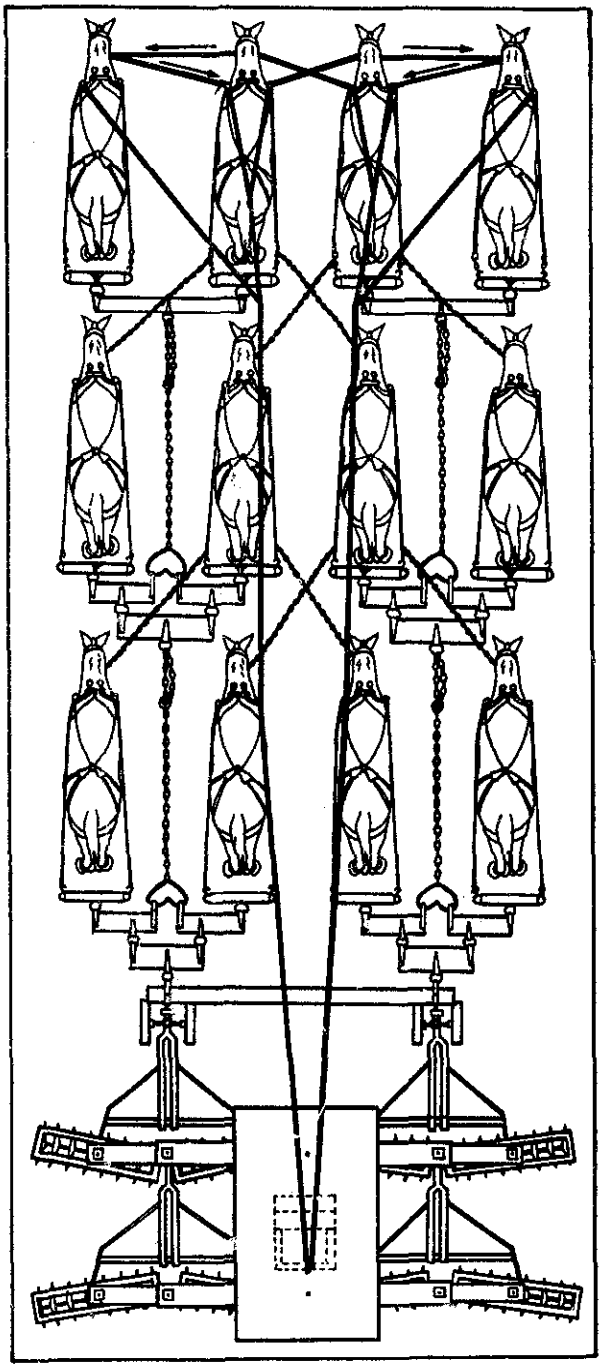
Disking is the greatest labor-saving soil tillage operation. On good farms it precedes and follows plowing. It pulverizes trash, kills weeds, conserves moisture and makes easier and better plowing. The 20-blade, ten-foot discs now available are usually drawn by six horses, but often need eight for steady progress, especially early in the spring when the horses are soft. One rule governs: Use "horse sense," and if you see the load is too heavy for the number of horses you are using, put on more, until there is enough power attached to allow the horses to walk at a good pace all day. You hire men to accomplish work, not to sit out in the field waiting for horses to rest and recuperate, and it is sound economy to furnish plenty of power, especially as one more horse, or a pair, will turn the balance between overload and ample power.

Plowing is heavy work, made worse by the general practice of crowding the horses too closely together and by failure to hitch on the true center of draft. On every plow, whether one-bottom or more, there is a point of hitch termed the center of draft and when the hitch is made at this point, the plow pulls with less exertion than when the hitch is made at a point more distant from the furrow. On a gang plow, two 14-inch bottoms, this center of draft is approximately 16 inches from furrow wall or 23 inches from the center of furrow when plows are cutting full, even furrows as they should. This means, therefore, that the eveners must be of such length, and the horses so hitched, as to give a straight forward pull over the true center of draft. This cannot be attained with four or more horses except by putting a horse or horses on plowed land, or by stringing the horses, so as to put the right-hand horse in the furrow and the others on solid ground. This causes the horses to pull the plows at great disadvantage, and the extra load thus created is called side draft.

Every farmer should recognize that it is just as easy to drive four, five, or six horses as it is to drive two, providing they are properly hitched; and the ease with which eight, ten, and even 16 horses are handled in the West by hired men who never before drove more than two or four is evidence, if proof be needed, that there is no real obstacle to multiplying the amount of work done per man per day. The size of the units, however, must depend largely upon the size of the farm. On a 100-acre farm, there are seldom more than 80 acres in tilled land, and four good horses are ample to operate such acreage. The implements purchased and the hitches used should therefore be based on a four-horse unit. This calls for six-foot discs with trailers (12-disc units), two-bottom gang plows of 14-inch bottoms and four-section harrows, together with seeders not over ten feet in length. Other implements should be proportionate. All these can be handled by four good horses, although if the ground is full of stones or ledges of rock, gang plows cannot be operated satisfactorily. Under such conditions, it is wise to use 14- or 16-inch walking plows with three horses, which are the oldest but most satisfactory plow units for use on such land.

On farms that have around 150 acres in tilled land, six good horses or mules will be needed. Here, with fields of 30 acres or over, six-horse units can be used on discs, plows, and harrows, which are the implements chiefly used in the preparation of the seedbed. It is in soil preparation that the greatest saving





A hitch for twelve horses on two tandem disc harrows cutting all hoof prints except on turns.

A dimension drawing of tandem hitch for eight horses pulling a three-bottom plow to maintain a true line of draft.

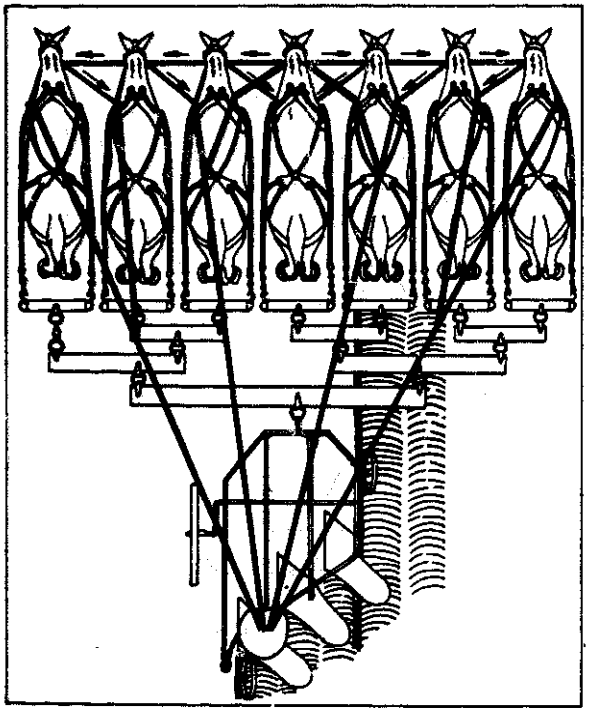
in manual labor can be effected. One man, by using six-horse units wherever possible, can handle all the work on a farm containing 150 acres of tilled land, until time for corn plowing, thus cutting down the need for an extra farm hand to the months of June, July, and August—three months instead of six.

On larger farms of 400 to 1,000 acres, the use of 7- up to 16-horse units on various farm implements is both practical and desirable.

The great advantage about this seven-abreast or nine-abreast hitch is that it gives an absolutely straight pull over the true center of draft and the horses are back next to the plow and are so hitched and driven as to make it possible for anyone to handle the team very easily. The only disadvantage that can be charged against the hitches in question is the fact that they require three or four of the horses to walk on the plowed land. The actual experience of men who have worked these seven, eight, or nine horses abreast on plows shows conclusively that this objection has no serious weight. The strongest, toughest horses, best able to withstand the work, should be put on the plowed land and they will keep pace with the others so that no slackening in mileage per day will result. The details of these hitches are fully shown in the illustrations.

Three-bottom gang plows (14-inch bottoms) will turn 8.4 acres per day; four-bottom gang plows (14-inch bottoms) will turn 11.3 acres per day; two eight-foot discs hitched abreast with trailer attachments (double disking a strip 16 feet wide) will double disk 38 acres per day; an eight-section harrow (five-foot sections) lapping one foot each round, will harrow 94 acres per day, and the three seeders (one 12 feet and two 11 feet) will seed 80 acres per day.

So it was in 1922, and so it can be again now that the population of draft horses is increasing, along with the availability of equipment, as the following listings illustrate.



Seven-horse-abreast hitch for a three-bottom plow.

NORTH AMERICAN SOURCES OF ANIMAL-DRAWN EQUIPMENT*

Manure Spreaders

The Bowman Model K

The Bowman Model K comes with a 102-by 18-inch box made of heavy pine floor and 12-gauge steel sides. Apparently the only horse-drawn spreader currently being produced in North America, the Bowman features chain drive, wide paddle beaters that do a good job of breaking up and spreading lumps, and either steel or rubber wheels. Its capacity is approximately 90 bushels.

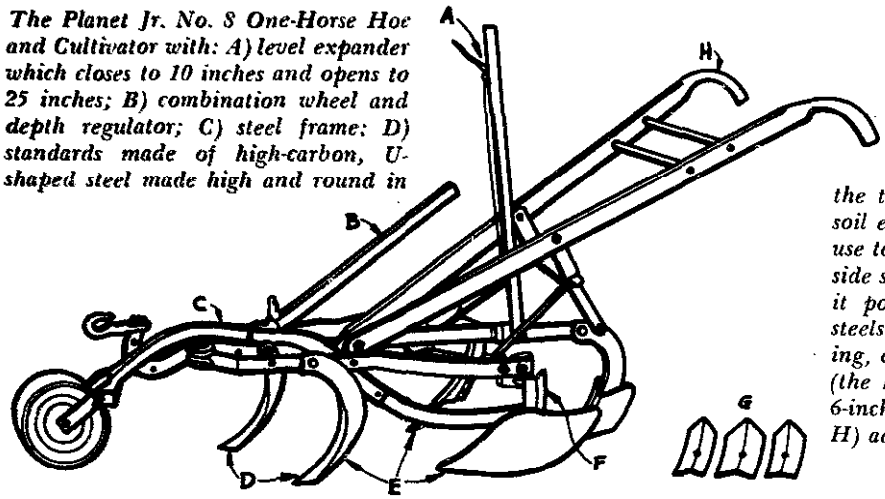
Bowman Model K
Bowman Mfg.
Hawkesville, Ontario, Canada

Plows and Cultivators

Planet Junior Number 8 One-Horse Cultivator

The venerable Planet Jr. comes with four 3-inch-by-8-inch cultivator steels, one 4-inch-by-8-inch cultivator steel, two 6-inch hillers, one 7-inch shovel, a level wheel, lever expander, and

* Listings of animal-drawn seeder/planter, threshing, winnowing, and cleaning equipment can be found in chapters five and seven.



The Planet Jr. No. 8 One-Horse Hoe and Cultivator with: A) level expander which closes to 10 inches and opens to 25 inches; B) combination wheel and depth regulator; C) steel frame; D) standards made of high-carbon, U-shaped steel made high and round in the throat to prevent clogging; E) soil engaging steels which polish in use to prevent soil adhesion; F) two side standards which swivel, making it possible to turn the hillers or steels to any angle desired for hilling, or cutting to or from the row (the hillers are reversible); G) two 6-inch hillers, one 7-inch shovel; H) adjustable hardwood handles.

depth regulator. Its side standards have the virtue of swiveling to permit turning the hillers to any angle desired for hilling, or cutting to or from the row.

Planet Junior Division
Piper Industries
P.O. Box 1188, Freeport Center
Clearfield, UT 84106

The Reliable Model 60

The lightest draft plow of its type, the Reliable Model 60 does a good job of plowing in any kind of soil and in all conditions. The rear weight of the plow is supported by a rolling landslide which serves as the third leg of a triangular rolling support. Uniform depth and width of furrows is controlled by the front furrow master wheel.

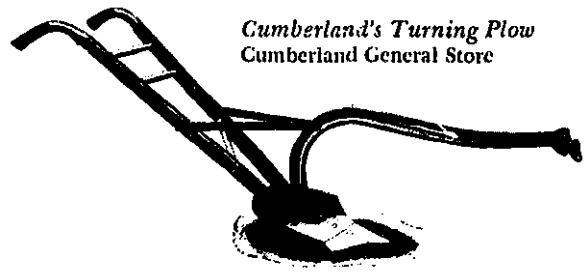
The sulky seat is placed to one side, well to the rear, and low down so that the operator has all levers within easy reach. Right- and left-hand models are available in 14-inch and 16-inch models.

Reliable Model 60 Sulky Plow
D.A. Hochstetler & Sons
R.R.2,
Topeka, IN 46571

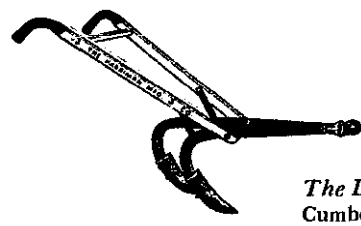
Cumberland General Store Plows

If you live in an area of the country where most horse-drawn equipment was abandoned and cut up for scrap around the time of World War II, you know that good pieces are hard to find. To help folks in this situation, the Cumberland General Store combs the countryside for used plows in good condition. These are then completely refurbished, with handles, points, and other parts being replaced where necessary. Each unit is cleaned, painted, and made ready for years of useful service. They are generally able to fill orders for turning plows, double shovel plows, and walking cultivators.

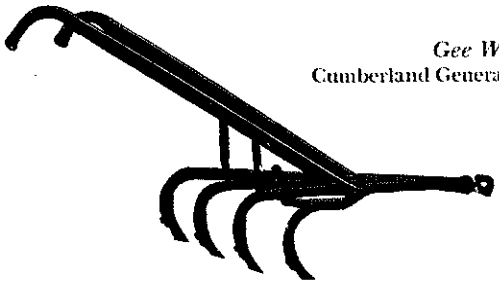
The Cumberland General Store also sells the Lynchburg Chilled Slat Moldboard Plow, a single-bottom plow designed for sticky clay soils where a conventional moldboard plow will not scour properly.



Cumberland's Turning Plow
Cumberland General Store



The Double Shovel
Cumberland General Store



Gee Whizzes
Cumberland General Store

New oak plow handles and plow stocks are also offered. The stocks are of the type that will accept any kind or style of blade that takes a heel bolt.

Other pieces of horse-drawn equipment available through the Cumberland catalog are Ferguson single-row planters, Rex guano distributors, and Old Blue riding-type fertilizer distributors.



Guano Distributor
Cumberland General Store

Cumberland General Store
Rt. 3
Crossville, TN 38555

International Modern Machinery, Inc.

International Modern Machinery, Inc. manufactures this complete set of implements for the small farm where water buffalo, cows, or oxen are used instead of tractors. The set includes: plow, disc, harrow, row maker, cultivator, fertilizer and planter distributing unit, and a piece of equipment used for leveling and draining the field. This set of equipment will allow the world farmer to put in his crop within a six- to eight-day period rather than a forty-five-day period usually required when using his existing equipment and hand labor, leaving enough time for another crop.

International Modern Machinery, Inc.
P.O. Box 790
Beaumont, TX 77704

Manufacturers of Harness and Horse-Drawn Equipment

The Arthur Collar Shop
R.R. 2, Box 59
Arthur, IL 61911

Berlin Pad Shop
Eli B. Yoder
Rt. 5
Millersburg, OH 44654

Perry E. Bontrager
Highway 1
Kalona, IA 52247

Brubaker's Harness Shop
Wallenstein, Ont., Canada

The Country Harness Shop
Stillman Valley, IL 61084

Cumberland General Store
Rt. 3
Crossville, TN 38555

Lester Detweiler
Detweiler's Harness Shop
Rt. 1, Box 228
Hazleton, IA 50641

Diamond Tool & Horseshoe Co.
P.O. Box 6246
Duluth, MN 55806

George Edwards
Walpole, NH 03608

Art Eller
Eller's Harness Shop
Pierz, MN 56364

Freeport Harness Shop
Freeport, ME 04032

Roy Fritzges
St. Edward, NB 68660

Gavitt Mfg. Co.
230 7th St.
Macon, GA 31201

Glen-Bel Enterprises
Rt. 5, Box 390
Crossville, TN 38555

Hamburg Plow Works, Inc.
1021 S. 4th St.
Hamburg, PA 19526

Vaughn Huston
Box 155
Early, IA 50535

G.A. Kelly Plow Co.
Longview, TX 75601

King Plow Co.
887 W. Marietta, NW
Atlanta, GA 30318

Mast Harness Shop
Rt. 2, Box 169
Arthur, IL 61911

Frank McGrath
New Richland, MN 56072

Miller Harness Shop
Topeka, IN 46561

Paul I. Murphy
Box 307, 314 Park St.
Danvers, IL 61732

Raber's Harness Shop
R.D. 5
Millersburg, OH 44654

Aaron Ramer
25928 S.R. 119, Rt. 5
Goshe, IN 48526

Rocky Sabatino
Rockland, ME 04841

Bernard P. Samson
956 S. W. 12th St.
Forest Lake, MN 55025

Schrock Harness Shop
Rt. 1
West Union, OH 45693

Shanahan's Harness Shop
R.R. 2
Maidstone, Ontario, Canada

Smith's Harness Shop
P.O. Box 43
Shawville, Quebec, Canada

Daniel R. Stoltzfus
1902 Pioneer Rd.
Lancaster, PA 17602
Hickory single & double trees

Wagner Supply Co., Inc.
6—1st St. NW
Hampton, IA 50441

The Wagon Master
Rt. 1, Box 446
O'Fallon, MO 63366

Windy Hill Farm & Harness Shop
85854 Doane Rd.
Eugene, OR 97402

Wm's Leather Shop
2952 30th St.
Allegan, MI 49010

The Yankee Peddler
10318 Sagamore Rd.
Leawood, KS 66206

Cornelius M. Yoder
Rt. 2
Topeka, IN 46571

NORTH AMERICAN SOURCES OF RELATED EQUIPMENT

Wagonmakers and Wheelwrights

Cumberland General Store
Rt. 3
Crossville, TN 38555

Robert Faller
Whalan, MN 55986

Glen-Bel Enterprises
Rt. 5, Box 390
Crossville, TN 38555

Hoosier Buggy Shop
Rt. 2
Topeka, IN 46561

Southwest Wagon & Wheel Works
Box 738
Patagonia, AZ 85624

Blacksmith and Farrier Equipment

Buffalo Forges
465 Broadway
Buffalo, NY 14204

Champion Farrier Tools
Champion Blower & Forge, Inc.
100 W. Central Ave.
Roselle, IL 60172

Cumberland General Store
Rt. 3
Crossville, TN 38555

Diamond Farrier Tools & Horseshoes
Box 6246
Duluth, MN 55806

Enderes Tool Co.
P.O. Box 691
Albert Lea, MN 56007
Blacksmith's tongs

Fisher and Norris
301 Monmouth
Trenton, NJ 08609
Anvils

Glen-Bel Enterprises
Rt. 5, Box 390
Crossville, TN 38555

Heller Tool
Heller Drive
Newcomerstown, OH 43832
Farrier's knives and pincers

Milwaukee Tool & Equipment Co.
2775 S. 29th St.
Milwaukee, WI 53215
Anvils

P.F. Peddinghaus, Inc.
261 First St.
Palisades Park, NJ 07650
Anvils

Draft Horse Publications *

Draft Horse Journal
Rt. 3
Waverly, IA 50677
$6/yr. (4 issues)

The Draft Horse Primer
Maurice Telleen
Rodale Press, Inc.
Emmaus, PA 18049
$10.95/386 pgs.
A guide to the care and use of workhorses and mules.

The Evener
Putney, VT 05346
$6/yr. (11 issues)

Small Farmer's Journal
Box 197
Junction City, OR 97448
$8.50/yr. (4 issues)

Workshops

Draft Horse Workshop
Clarksburg, MA 01247

Hillcraft School of Horseshoeing
10890 Deer Creek Canyon Rd.
Littleton, CO 80120

Office of Continuing Education
North Adams State College
North Adams, MA 01247

* Subscription prices quoted for 1977.

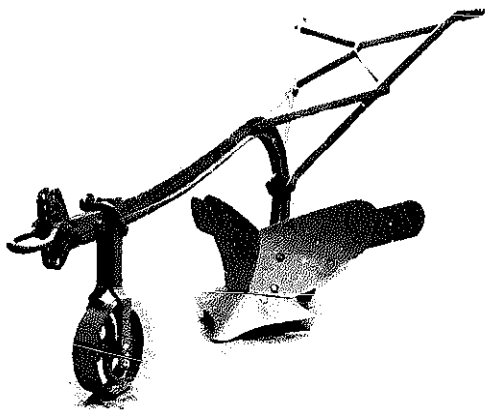
INTERNATIONAL SOURCES OF ANIMAL-DRAWN EQUIPMENT

Ridgers

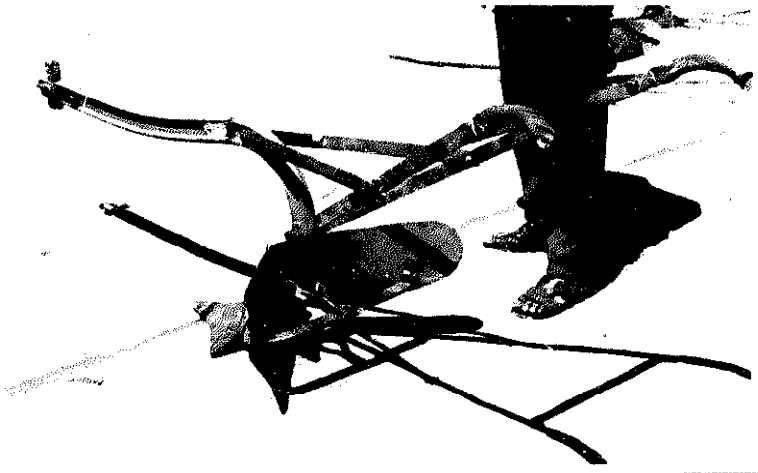
Kapas (Emcot) Ridger

The beam, moldboards, and handles of this ridging plow are made from steel. The moldboards can be fitted with extension pieces to increase the working width. Weight: 44 kilograms.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India



The Cossul Emcot Ridger Cossul & Co.



An Emcot Ridger Plow made by blacksmith Malun Ibrahim Musa of Funtua, Nigeria.

Emcot S30B Ridger

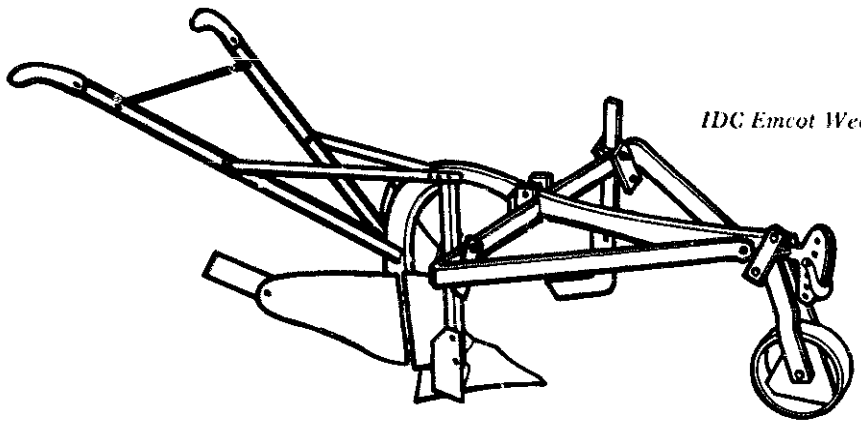
This all-metal ridging plow is fitted with moldboards which are adjustable for widths of 63 to 100 centimeters or, if the moldboard tailpieces are removed, widths of 51 to 74 centimeters.

The body is designed to form a wide-based, rounded-top ridge. The implement is generally pulled by two oxen. Weight: 49 kilograms.

John Holt, Agricultural Engineers, Ltd.
P.O. Box 352
Zaria, Nigeria

ITDG Plans for IDC Emcot Weeding Attachment

The weeding attachment designed at the Industrial Development Centre in Zaria for use with the Emcot ridger and one or two oxen consists of a frame which is attached to the Emcot beam and carries two weeding tines, set in front of the Emcot moldboards. The tool standards can be adjusted for height and width according to the row spacing. The weeding knives run close to the plants and dig deep enough to cut down the sides of the ridges. The sides of the ridges are remade by the ridger body following behind. Modifications to the frame were made to simplify manufacture without affecting the functioning of the attachment. Four examples of the modified attachment were commissioned from a local blacksmith and tested by Daudawa Settlement farmers during 1973. The weeding performance was good where the farmers had made uniformly spaced, parallel ridges.



IDC Emcot Weeding Attachment

The Emcot ridger with weeding attachment was easy to control if the Emcot depth wheel was used, but Daudawa farmers do not normally use the wheel and were adamant in their refusal to use it during the trials. Without the wheel, the front of the Emcot beam tended to swing from side to side and the weeding tines swung with it, causing crop damage. This damage was reduced in a modification where the tines were set further back on the implement, but this was still not as satisfactory as using the wheel.

ITDG Report on the Dahomey Emcot Weeding Attachment

A very cheap and simple attachment to the moldboards of a ridging plow, designed and used with success for weeding in the northwest area of Dahomey, was constructed and tested. It was found to function well only in the sandiest fields in the Daudawa area. For the 1973 season, three pairs of Emcot moldboards with these weeding attachments were commissioned from a local blacksmith and sent for testing to Kafin Soli, an agricultural station 150 kilometers north of Daudawa. It was reported that the attachments worked well and seemed to be suitable for that soil type, which is sandier than that of Daudawa and similar to that of the northwest of Dahomey.



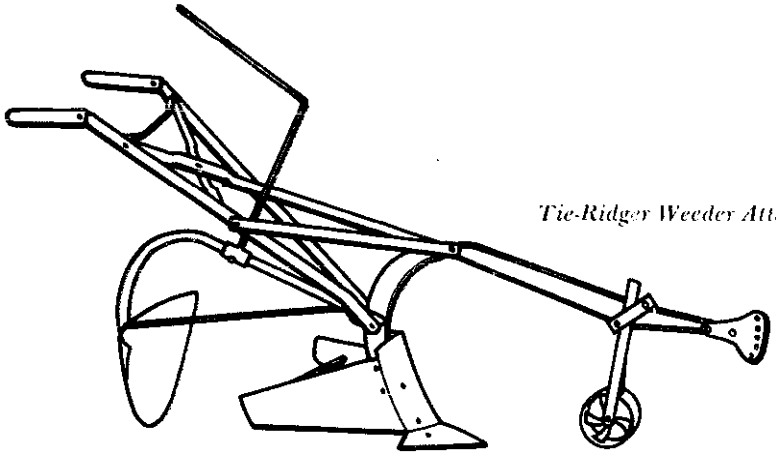
Close-up view of Dahomey moldboard extensions on an Emcot Ridger Plow.

Plans For Ox-Drawn Tie-Ridger/Weeder Implement (Attachment to Emcot Ridging Plow)

This attachment was developed by the International Development Center in Zaria, Nigeria to allow ridged row crops to be weeded by animal power rather than by hand. The plow, with weeding attachment, can be pulled by one or two oxen. Tool standards can be adjusted for height, and also for width according to the row spacing. The weeding knives should be run close to the plants without damaging the roots, and should dig deep enough to cut down the sides of the ridges. The ridges are re-formed by the ridger body following behind.

Adjustable-Width V-Drag Ditcher/Bund Former Plans

This implement, developed by the United States Department of Agriculture, can be used for making irrigation ditches, and also for con-

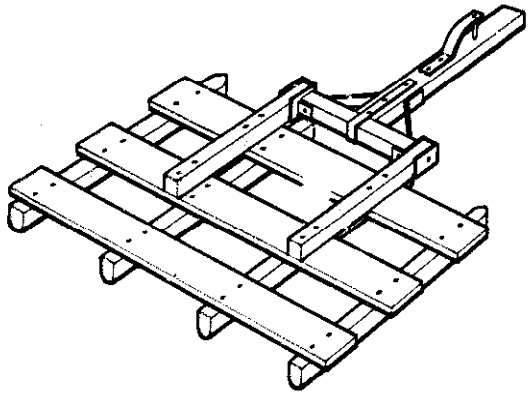


Tie-Ridger Weeder Attachment to the Emcot Ridger Plow

struction of low-height contour bunds for border irrigation. When making earth ditches, a furrow is first opened with a plow along the line of the ditch. The V-drag is then used with the runner board riding in the furrow bottom, the crowder board deflecting the soil sideways. When using the V-drag to construct contour bunds for irrigation, a plow is run down and back twice, throwing the soil into the border line. The implement is then run down the line, the crowder board pushing the soil into a ridge.

Sled-Type Corrugator/Irrigation-Furrow Former Plans

Designed by the United States Department of Agriculture, this implement can be used to make small furrows or corrugations for distributing water over a field. This implement can be used after the field has been broadcast seeded or before row-crop planting. The design can be modified to suit animal draft or tractor hitching as required.

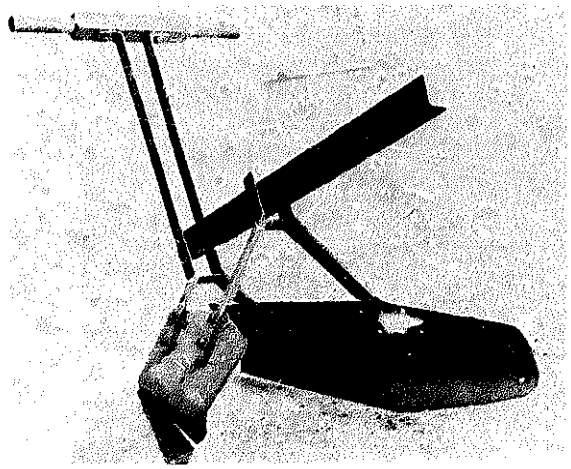


Sled-Type Corrugator/Irrigation-Furrow Former

All the above plans are available from:
Intermediate Technology Publications, Ltd.*
9 King St.
London WC2E 8HN, England

Bund Former

This is a simple labor-saving implement for forming bunds or ridges in the preparation of a field for irrigation. It is also used in dry farming areas to preserve moisture. On deep slopes bunds are made across to prevent washout during heavy rains. The main parts are a pair of collecting



Cossul Bund Former
Cossul & Co.

* All Intermediate Technology publications can be ordered from International Scholarly Book Services, Inc., Box 555, Forest Grove, OR 97116

moldboards of steel. They are so fitted so as to collect soil and throw it on the center to make a bund. Size of bund and soil-collecting capacity can be increased or decreased by adjusting the moldboards.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

Safim High-Wing Ridger

Wings adjustable from 400 to 760 millimeters width. Weight: 43.6 kilograms.

Massey Ferguson (South Africa), Ltd.
P.O. Box 677, Steel Road
Vereeniging 1930, South Africa

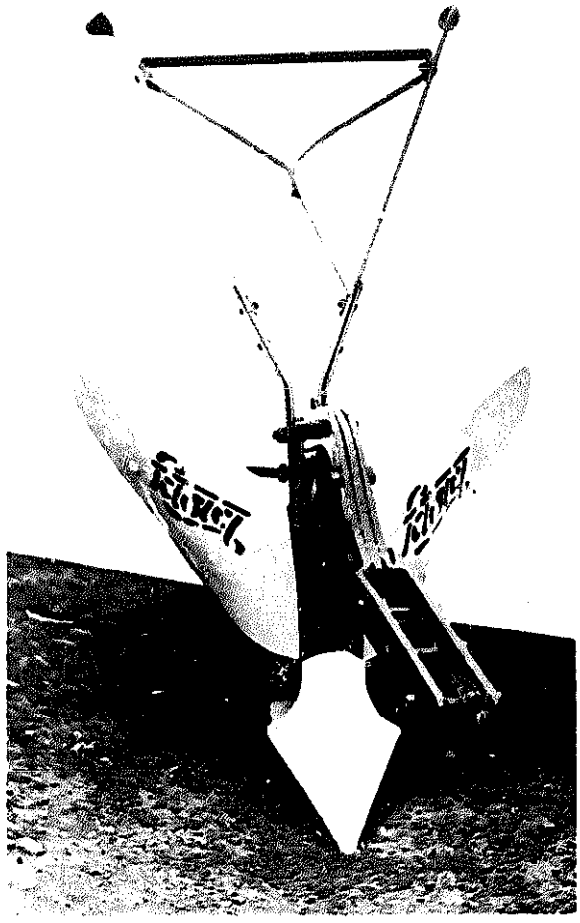
Vijay Ridger

A medium-size ridger designed especially for use in sugar cane. Wings are adjustable for different ridge sizes. Pulled by two pairs of bullocks, it can work at depths of 22 to 25 centimeters and make ridges at 60 to 90 centimeters spacing.

New Vijay Industries, Ltd.
Vishrambag, Sangli 416 415
Maharashtra, India

Ox-Drawn Ridger

Ubungo Farm Implements
P.O. Box 2669
Dar-Es-Salaam, Tanzania



The Vijay Ridger



An ox-drawn, one-row ridger/furrower

Delta (Bihar Type) Ridger

This is a long-beam ridging plow fitted with adjustable width moldboards. Weight: 40 kilograms.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

Ridger Plow

Animal-drawn steel plow with wooden beam. Width of cut is 100 millimeters, depth of cut is 225 millimeters, draft 50 to 65 kilograms.

Rajasthan State Agro Industries Corp., Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006, Rajasthan, India

Ridger Plows

These ridgers are available with a long wooden beam or with a short steel beam and depth wheel. The moldboards are adjustable on both models.

Danishmand & Co.
Karkhana Bazar
Lyallpur, Pakistan

Care and Subhash Plows

These are general purpose, long-beam moldboard plows. They feature extra high clearance under the beam for work in weed-infested fields. The positions of the beam and handles relative to the plow body can be easily adjusted. Weight: 10.5 to 14.5 kilograms according to model.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

Balwant Plow

A common type of Indian plow, made of wood with iron wearing parts. Pulled by a pair of small bullocks, it works to a depth of 15 to 20 centimeters and width of 22 to 25 centimeters. Weight: 42 kilograms.

New Vijay Industries, Ltd.
Vishrambag, Sangli 416 415
Maharashtra, India

Chota Plow

This plow has a long wooden beam and a steel moldboard. Pulled by one pair of small bullocks, it makes a furrow 8 to 10 centimeters deep and 10 to 15 centimeters wide. Weight: 18 kilograms.

New Vijay Industries, Ltd.
Vishrambag, Sangli 416 415
Maharashtra, India

Rajasthan Plows

Animal-drawn, left hand, steel moldboard plows with wooden beams. There are two models, No. 1 for medium and heavy soils, No. 3 for light soils.

	No. 1	No. 3
Width of cut	175 mm	150 mm
Depth of cut	75-125 mm	75-125 mm
Draft	70-80 kg	60-70 kg

Rajasthan State Agro Industries Corp., Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006, Rajasthan, India

Bose Super Plow

Single-furrow and two-furrow models available with either wooden or steel beams.

V.M. Thevar & Sons
Melur, Madurai Dist.
Tamil Nadu, India

Meston and Danish Plows

These are long-beam plows with inverting-type moldboards which can work to a depth of 150 millimeters and a width of 200 millimeters.

Danishmand & Co.
Karkhana Bazar
Lyallpur, Pakistan

Shabash and Praja Plows

These long-beam inverting-type moldboard plows are designed to be pulled by two bullocks. They plow furrows approximately 150 millimeters wide and 100 to 150 millimeters deep.

Sharda Engineering Works
105/661 D, Fahimabad
Kanpur 208 005, India

Vijaya (Victory) Plow

This is a strong, all-steel plow. A head wheel is provided to control the depth. It cuts a furrow 225 millimeters (9 inches) wide and 100 to 150 millimeters (4 to 6 inches) deep. Weight: 38 kilograms. Area covered: 0.3 to 0.4 hectares/day.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

Dandekar Steel Plow

Moldboard plow with steel beam and forged steel share. It furrows 12 to 20 centimeters in width and 6 to 18 centimeters deep. Weight: 35 kilograms.

Dandekar Brothers (Engineers and Founders)
Sandli
Maharashtra, India

Safim Plows

These plows are available in VS models for general purpose plowing or IS models with higher clearance for use in trashy conditions.

Model	Cut	Weight
VS 8	200 mm (8″)	39.5 kg (87 lb.)
VS 10	250 mm (10″)	40.0 kg (88 lb.)
VS 12	300 mm (12″)	45.5 kg (100 lb.)
IS 12	300 mm (12″)	49.5 kg (109 lb.)

Massey Ferguson (South Africa), Ltd.
Steel Road, P.O. Box 677
Vereeniging 1930, South Africa

Walking Plow

Designed for light and medium soils. Comes in three sizes ranging from 24 kilograms to 31 kilograms in weight.

Agromet-Unia
Foreign Trade Enterprise
00-950 Przemyslowa 26
Warsaw, Poland

Walking Plow with Support Wheel

This horse-drawn walking plow is intended for use in light- and medium-cohesive soils in small fields and gardens. They are also recommended for plowing wedges and other intricate field shapes. Weight: 37 kilograms.

Agromet-Unia
Foreign Trade Enterprise
00-950 Przemyslowa 26
Warsaw, Poland

Swing Plow—Model V.B.

This moldboard plow is available with a front wheel or forefoot and with or without coulter, skimmer, or spare share. It comes in three sizes.

W. Hertecant
9200 Kwatrecht
Wetteran, Belgium

Two-Bottom Plows

Horse-drawn, double-furrow frame plows designed for light and medium soils. Frame is supported by two wheels. Weight: 96 kilograms.

Agromet-Unia
Foreign Trade Enterprise
00-950 Przemyslowa 26
Warsaw, Poland

Fixed Moldboard Plow

Pulled by one pair of bullocks, it plows a furrow 8 to 20 centimeters deep and 12 to 22 centimeters wide. Weight: 36 kilograms.

New Vijay Industries, Ltd.
Vishrambag, Sangli 416 415
Maharashtra, India

At 35 Plow

This plow consists of a one-piece forged beam, soil-engaging parts of heat-treated steel, steel handles, depth control wheel, and draft chain. Weight: 23.3 kilograms.

Société Des Forges Tropicals
B.P. 706
Douala, Cameroun

Moldboard Plow
Ubungo Farm Implements
P.O. Box 2669
Dar Es Salaam, Tanzania

Raja and Victory Plows

These are short-beamed, chain-drawn plows and can be supplied with wooden frame (Raja) or all steel construction (Victory).

Danishmand & Co.
Karkhana Bazar
Lyallpur, Pakistan

CF 000 P Plow

This ox plow has steel wearing parts. Working width is 25 centimeters; maximum working depth is 20 centimeters. Weight: 38 kilograms.

Siscoma
BP 3214
Dakar, Senegal

Punjab Plow

This is a heavy, short-beam plow designed to be pulled by two bullocks. It is capable of plowing a furrow 125 to 150 millimeters deep and 150 to 20 millimeters wide.

Sharda Engineering Works
105/661 D, Fahimabad
Kanpur 208 005, India

Turnwrest Plow

This ox-drawn turnwrest plow was specially developed for use across hilly slopes and for horticultural work where a level seedbed is important. It is normally fitted with two handles and a wheel, and is manufactured in two weights, 33 kilograms (73 pounds) and 40 kilograms (90 pounds).

The body is pivoted under the plow beam and locked in position by a lever.

ETS. A. Bourguignon
B.P. 17
26300 Bourg de Peage
Drome, France

Reversible Plows

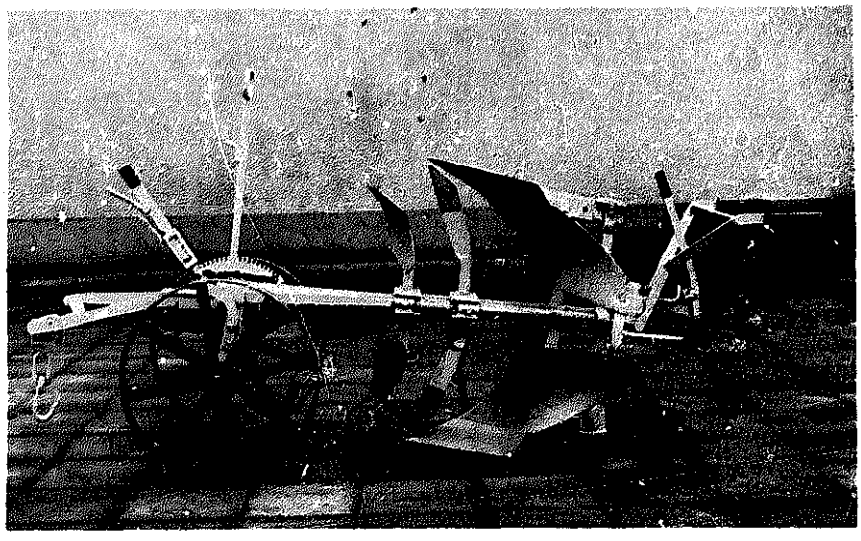
Animal Draft Reversible Plow

Available with plain or ribbed moldboard and wooden or steel pipe frame construction.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Turnwrest Plow

The turnwrest plows are capable of turning furrows either to the right or left. At the end of the furrow the plow bottom can be reversed by releasing the hook at the back of the breast, swinging the body under the frame into corresponding position on the opposite side, and



Hertecant Reversible Plow LEIE-9
Willem Hertecant

replacing the hook. The plow is supplied with a double steel handle, steel beam, cast breasts and self-sharpening cast-chilled shares. A headwheel is provided to give required depth. Available in different sizes from 150 to 250 millimeters. Weight: 43.0 kilograms.

Hertecant Plow—LEIE-9 Model

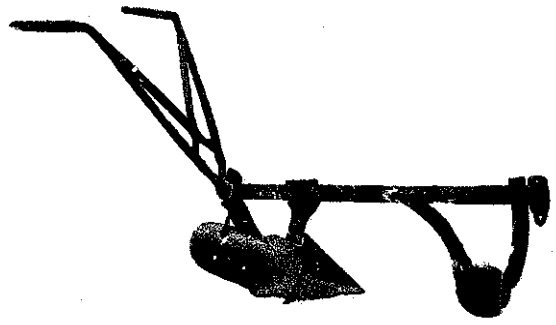
Characteristics of this model include a fixed beam and double handle; reversible elements on the rear; three easy adjustments for traction, depth, and angle correction; all wearing parts are interchangeable and skimmers are available as options.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

W. Hertecant
9200 Kwatrecht—Wetteren
Belgium

Turnwrest Plows

A range of turnwrest or reversible plows is available from this company.



Cossul Turnwrest Plow Cossul & Co.

New Vijay Industries, Ltd.
Vishrambag, Sangli 416 415
Maharashtra, India

PLOW	POWER REQUIRED	WORKING DEPTH	WORKING WIDTH	WEIGHT
No. 1 (ill.)	4-5 pairs bullocks	20-25 cm	30-35 cm	96 kg
No. 2	3-4 pairs bullocks	15-20 cm	30-35 cm	86 kg
No. 3	1-2 pairs bullocks	13-15 cm	23-25 cm	55 kg
Vasant	1 pair bullocks	10-13 cm	15-18 cm	46 kg
Berar	1 pair bullocks	15-18 cm	15-20 cm	30 kg

Toolbars

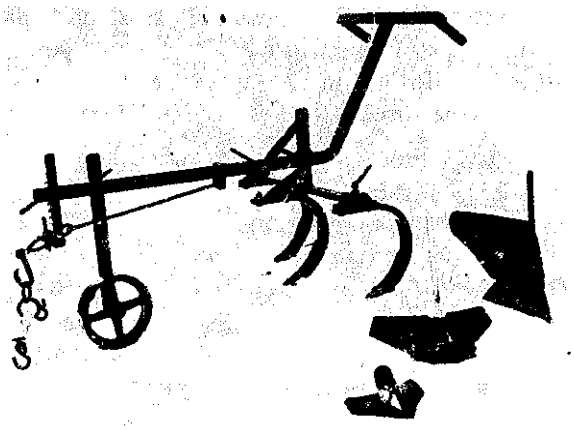
Ox Plow

A two-handled plow fitted with wheel, hake adjustment, and knife coulter. It is made in four sizes, weighing from 51 to 113 pounds (23 to 50 kilograms). Attachments are available for ridging, sweep cultivation, and tined cultivation.

ETS. Techine
82400 Valence d'Agen
France

Tom and BM Plows

Three animal-drawn, single furrow, mold-board plows can be supplied, weighing 14, 22, or



ETS. Techine Ox Plow

23 kilograms. Single or double steering handles are available. Ridging and sweep tine cultivation attachments are available for these plows.	ETS. A. Bourguignon B.P. 17 26300 Bourg-de-Peage Drome, France

THE MOCHUDI TOOLBAR, THE MAKGONATSOTLHE

Editor's note: This report from the Agricultural Information Service in Botswana, Africa, describes a localized need and the development of an implement to satisfy it.

For a number of years the Mochudi Farmers Brigade has been working to develop and perfect a multipurpose farming implement suited to local conditions. The need for improved implements arises because those which are currently available for draft animals are not suited to the semiarid conditions of Botswana and are generally of poor design.

Farmers are often hindered when their equipment breaks down and they are unable to find a mechanic capable of making repairs. Some have tried planters but, due to poor construction, failed to get satisfactory results and concluded that planters are useless. Another common problem is an insufficient number of fit draft animals to perform operations in a reasonable amount of time.

Because of these and other constraints, many farmers continue with the traditional broadcast-plow method of cropping. Using this method, only fair yields are obtained even in years of above-average rainfall, and in poorer years, a total crop failure may result.

A farmer can only be successful in growing good crops if his equipment can cope with the work in the time available. It is essential to reduce, if not eliminate, the frequency of total crop failure and at the same time produce good crops in most years. In order to do this in a semiarid climate with erratic rainfall distribution, principles of conservation tillage must be applied.

By combining features borrowed from a number of existing implements and ideas gained from consultation with tillage experts from a number of universities in North America, the design of the present Mochudi Toolbar came about. When the implement was introduced to the public in April, 1973, it was given the local name, the *Makgonatsotlhe,* meaning "the machine which can do everything." The name is considered fitting, since almost any type of cultivation tool can be attached to it, and it can also be used for carting or transporting drums of water. By removing some of the components from the toolbar, a walking model can be obtained which allows inter-row cultivation when crops are taller.

The heavy angle iron frame of the Mochudi Toolbar is supported on two pneumatic tires which allow the frame to be lowered or raised mechanically for depth gauge control by pulling back on a lift handle. The frame will support a planter unit, fertilizer applicator, disc hiller/furrowers, sweeps for stubble mulching, and a transport cart.

Further information is available from:

Mochudi Farmers Brigade
Box 208, Mochudi
Republic of Botswana, Africa

Donkey Plow

This very simple, lightweight plow weighs 29 pounds (13 kilograms). It can be fitted with either a moldboard or a ridging body.

ETS. Techine
82400 Valence D'Agen
France

OD2 Ridger/Plow

This tool frame can accept either of two types of ridging body, or an adjustable moldboard plow. The frame is of lightweight but heavy-gauge rectangular section steel tube, and is all-welded. The handles are adjustable for height, and on the lister-type ridger the pitch of the body is also adjustable. Either a wheel



OD2 Ridger/Plow The Goodearth Group

or a skid is used for depth control. The slade and the steering fin are individually adjustable on all attachments.

Project Equipment, Ltd.
Industrial Estate, Rednal Airfield
West Felton, Oswestry
Salop SY11 4HS, U.K.

ST21 Plow/Ridger

The frame of this implement can be fitted with a moldboard plow body or with an adjustable-width ridging body.

Gebruder Eberhardt
D79 Ulm, Donau
B.P. 204, Germany

Three-in-One Implement

The frame of this implement is of steel construction. Attachments are supplied for moldboard plowing (three sizes are available), ridging, and hoeing. Two handles and a depth wheel are provided. The angle between the soil-engaging parts and the wooden beam can be easily adjusted by a screw mechanism.

The Goodearth Group
16 Asaf Ali Rd.
New Delhi 1, India

E.B.R.A. Omniculteur

This toolbar consists of a backbone-type frame and handles. Clamps allow fitting of a depth wheel, moldboard plow, and a ridging body, wide-sweep tine. Transverse frame extensions can be fitted to carry up to five rigid or spring-type cultivator tines.

E.B.R.A.
28 rue de Maine, B.P. 84
49009 Angers, France

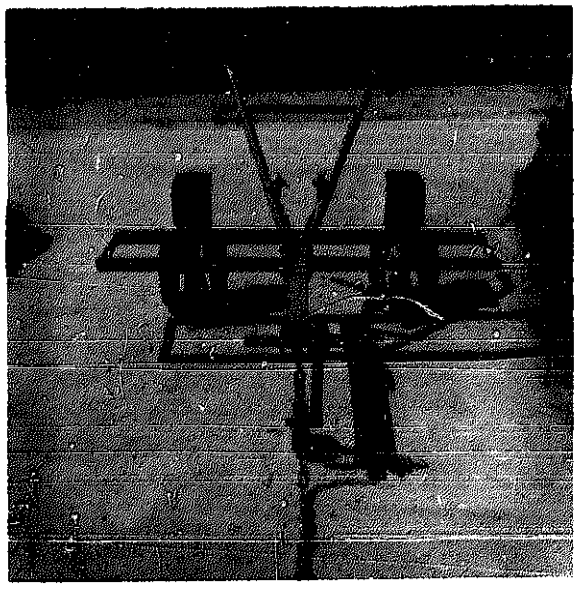
Arara Multicultivator

This is a backbone frame toolbar with depth wheel and handles. The following attachments can be fitted by means of two bolts: moldboard plow; ridging plow; groundnut lifter; spring-tine hoe with three or five tines.

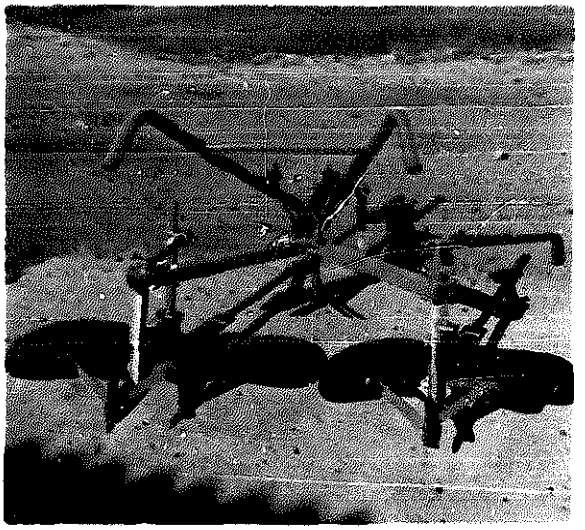
Siscoma
BP 3214
Dakar, Senegal

Unibar

This lightweight, multipurpose, animal-drawn implement was designed for use in the more arid areas of the tropics. It is made from square-section bar and square-section hollow tubing and is fitted with two skids for support. The tool can be used for plowing, ridging, ridge splitting, weeding, hoeing, rigid- and spring-tine cultivating, rotary cultivating, planting, row crop



Unibar with seeder attachments
The Goodearth Group



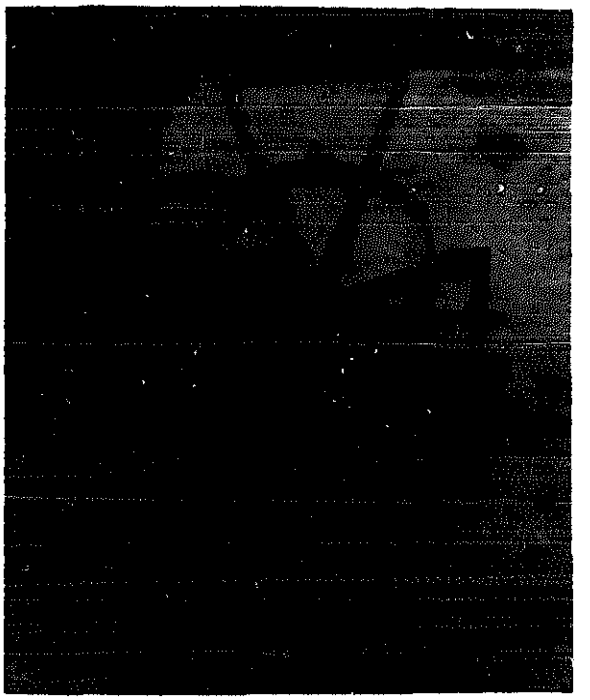
Unibar with two ridging plows
The Goodearth Group

lifting, and carting. Originally designed for farming on the ridge, it can be used as a single-row tool for inter-row cultivation up to a late stage in the growth of taller varieties of tropical crops.

Project Equipment, Ltd.
Industrial Estate, Rednal Airfield
West Felton, Oswestry
Salop SY11 4HS, U.K.

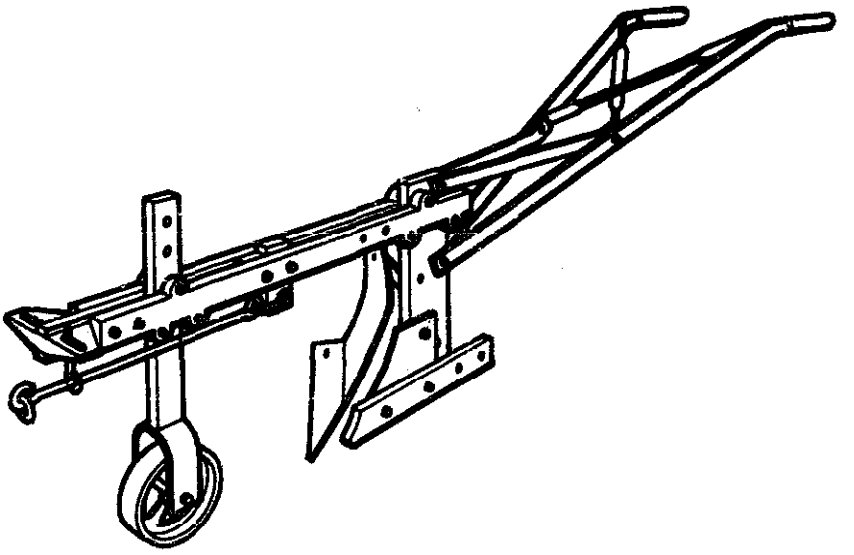
Heavy-Duty Unibar

This is a multipurpose, animal-drawn implement designed for heavier soils where extra



Heavy-duty Unibar with a groundnut lifter
The Goodearth Group

weight is essential to maintain penetration. It can handle the full range of standard Unibar attachments apart from the transport cart and, in addition, a 20-centimeter-cut general purpose plow, a lister-type ridger, a two-furrow semi-digger plow, and a 1.22-meter-wide 17-tine harrow. Up to four units of a new design of roller/seeder can be fitted behind the harrow so that crops such as wheat, rice, and soy beans can be



Chitedze Ridgemaster toolbar

planted in closely spaced rows. On this implement, the hitch and handles are fully adjustable.

Wide or narrow detachable V-pieces are used to carry the side stalks, to which various tools can be left assembled and merely bolted up to the frame when required. For plowing and ridging, the frame reverts to a width no greater than that of a conventional single-purpose plow or ridger.

Project Equipment, Ltd.
Industrial Estate, Rednal Airfield
West Felton, Oswestry
Salop SY11 4HS, U.K.

Chitedze Ridgemaster Toolbar Plans

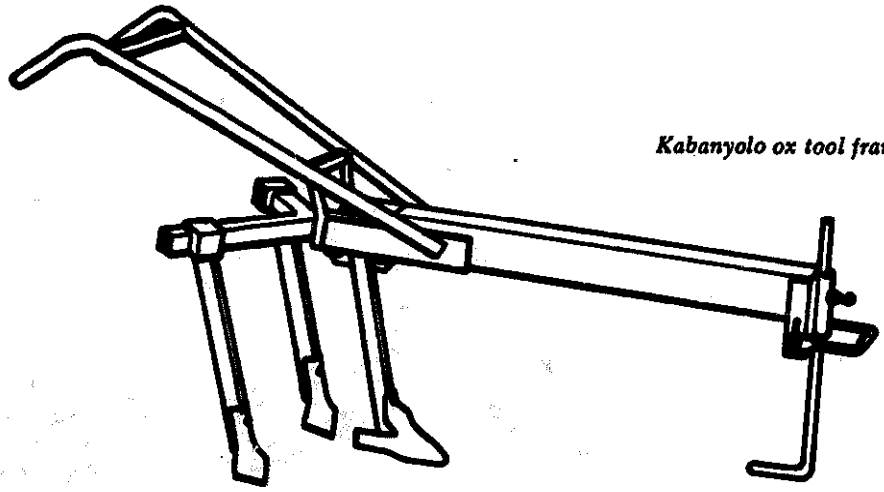
This multipurpose tool bar is shown here and in plan views with a plow body attached, but a ridger or cultivator can also be fitted to the vertical beam. The unique design feature of this toolbar is that it combines lightness with adequate structural strength, the main parts being fabricated from rectangular, hollow-section (R.H.S.), mild steel.

Kabanyolo Ox Tool Frame Plans

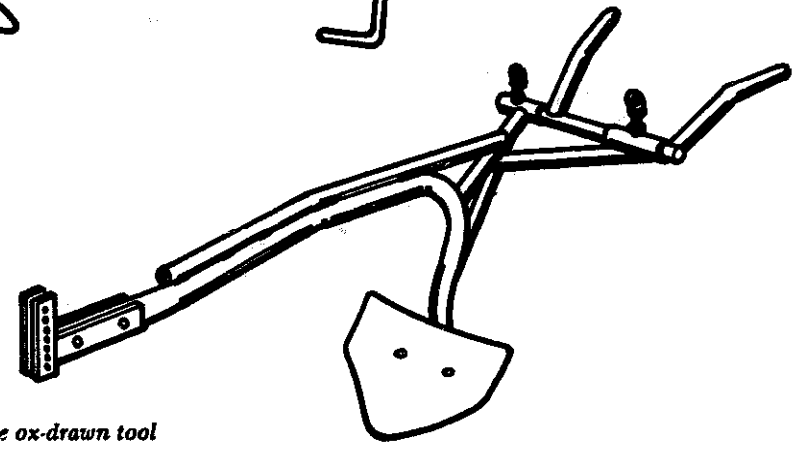
This multipurpose tool frame is shown here and in plan views with a plow stem attached. When fitted with the Y-frame, it can be used as an adjustable-width, three-tine cultivator/weeder. The tool frame is fabricated from flat steel, angle iron, and round bar. A simple skid is used instead of a depth wheel.

Prototype Multipurpose Ox-Drawn Tool Plans

Designed specifically for the farmer growing crops on ridges, the share on this multipurpose tool is adjustable to four settings: approximately 40, 55, 70 and 85 degrees. On the comparatively heavy soils at Samaru, Nigeria, the share was used for ridging, splitting ridges, cross-tying, weeding, and breaking capped soils in the fur-



Kabanyolo ox tool frame



Prototype multipurpose ox-drawn tool

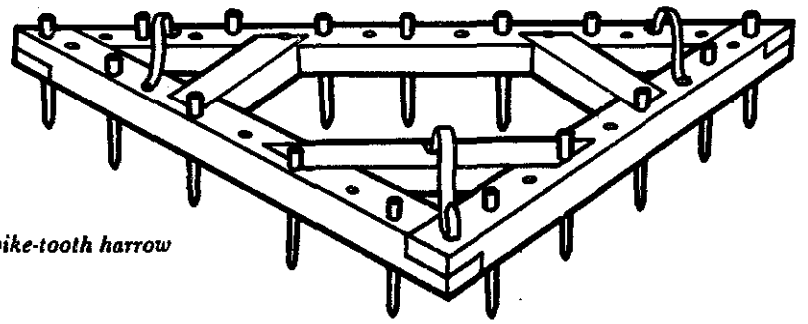
rows. The tool frame was designed with an offset beam to avoid blockage when lifting groundnuts. Though only a prototype, the design shows a considerable amount of ingenuity.

Above plans available from:
Intermediate Technology Publications, Ltd.
9 King St.
London WC2E 8HN, England

Harrows

I.T. Triangular Spike-Tooth Harrow Plans

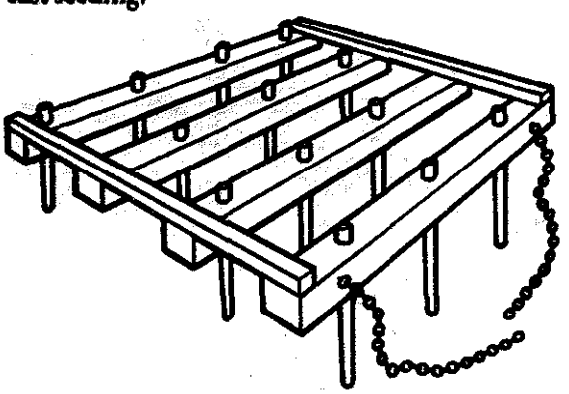
Originally designed in India, the teeth of this harrow can be made of hardwood or mild steel. Tooth spacing can be varied to suit soil conditions by removing teeth for wider spacing or by drilling holes and inserting teeth for closer spacing. The harrow can be used for preparing a seedbed, after plowing, and for covering seed after broadcasting. The harrow can be loaded with logs or stones to give greater penetration. For transport to and from the field, the harrow is turned on its back and run on the skids.



Triangular spike-tooth harrow

I.T. High-Clearance Peg-Tooth Harrow Plans

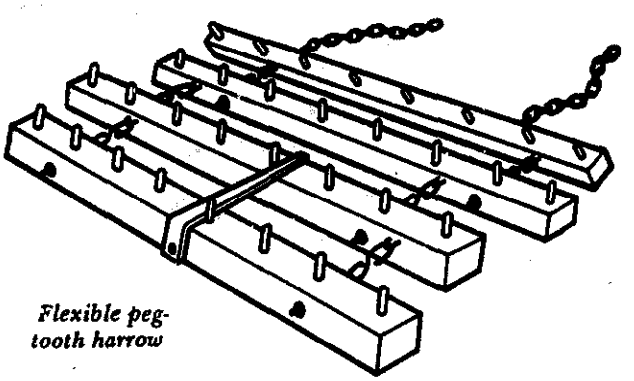
This harrow, constructed entirely of timber, was developed by the Ministry of Agriculture in Tanzania. Its high ground clearance and wide tooth spacing make it suitable for working in minimal tillage systems where it is advantageous to leave a trash cover on the soil surface. It can be used to break down soil clods before crop planting and for covering of seed after broadcast seeding.



High-clearance peg-tooth harrow

I.T. Flexible Peg-Tooth Harrow Plans

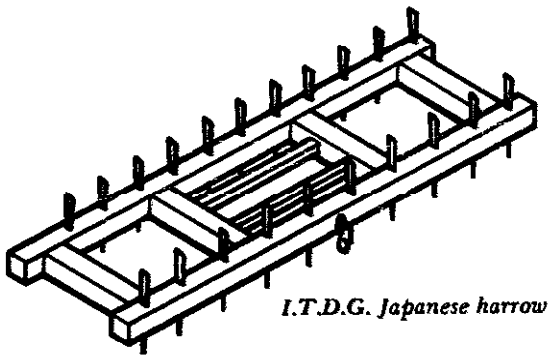
A locally built design from Iran, this low-cost peg-tooth harrow is designed for animal or tractor power. The flexible linkage between the bars helps make the harrow self-cleaning, and the linkage arrangement is designed to keep the teeth upright while in use. The bars are offset to give an average tooth spacing of 2 inches.



Flexible peg-tooth harrow

Japanese Harrow Plans

A simple, rigid, two-row harrow, this implement has a cutting action with the narrow edge of the teeth parallel to the line of draft. The flat, steel teeth are spaced 6 inches apart in each row.



I.T.D.G. Japanese harrow

Above plans available from:
Intermediate Technology Publications, Ltd.
9 King St.
London WC2E 8HN, England

Allied Disc Harrow

This is a versatile implement for crust breaking and seedbed preparation. Six-disc and eight-disc models are available. The angles of the discs are adjusted by a hand lever and a seat is provided for the operator. The implement can also be used as a threshing roller. Working width: .80 meter. Working depth: 50 to 110 millimeters. Draft: 40 to 50 kilograms.

Allied Trading Co.
Railway Rd., Ambala City 134 002
Haryana, India

Cossul Disc Harrow

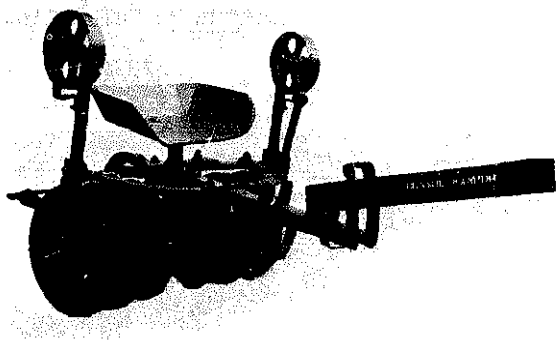
This is a versatile implement suitable for breaking clods to prepare a seedbed and also for puddling rice fields. It can also be used as a threshing roller. The discs are provided with scrapers. Weight: 6-disc model, 38 kilograms; 8-disc model, 92 kilograms.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

Disc Harrow

Heavy-type, all-steel with six discs of 38-centimeters diameter. Adjustable. Fitted with seat.

Rajasthan State Agro Industries Corp., Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006, Rajasthan, India



Cossul Six-Disc Janta Disc Harrow
Cossul & Co.

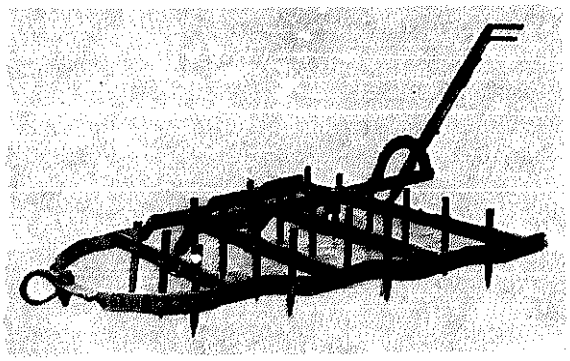
SAECO Bullock-Drawn Disc Harrows

Fitted with six discs, each 41 centimeters in diameter, and a central cultivator tine. The angle of the discs is adjustable. This harrow comes complete with transport wheels. Weight: 104 kilograms.

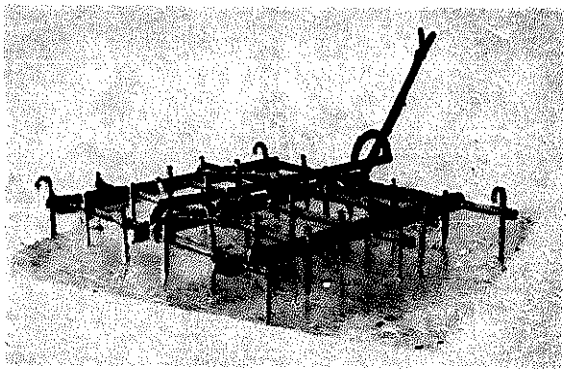
Standard Agricultural Engineering Co.
824/825 Industrial Area B
Ludhiana A-141 003
Punjab, India

Peg-Tooth Harrow

This harrow is suitable for preparing seedbeds, for crust breaking or for covering seeds after sowing. The tooth angle can be adjusted by a lever. Skids are provided for easy transportation. Weight: 18-tooth size, 27 kilograms; 25-tooth size, 33 kilograms; 30-tooth size, 51 kilograms.



Cossul Peg-Tooth Harrow with 18 teeth
Cossul & Co.



Cossul Peg-Tooth Harrow with 30 teeth
Cossul & Co.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

Disc Harrow Type PSP

This disc harrow is all metal and can be supplied with six to 12 discs with working widths of 2.5 to 7 feet (0.85 to 2.00 meters). In each case the angle of the discs can be adjusted, and the disc gangs are interchangeable so that discs can throw either inwards or outwards. The six- and eight-disc models can be increased to 8 and 20 discs respectively. Transport wheels and a central tine to work between the gangs can be supplied. A seat is supplied and scrapers are fitted to all discs. Weight varies from 327 to 463 pounds (147 to 208 kilograms).

ETS. Techine
82400 Valence D'Agen
France

Other Sources of Disc Harrows

International Mfg. Co. (REGD.)
Hospital Rd.
Jagraon, Ludhiana
Punjab, India

Kumaon Agri-Horticulture Store
P.O. Kashipur, Dist. Nainital
U.P., India

Mohinder & Co. Allied Industries
Kurali, Dist. Ropar
Punjab, India

Spring-Tine Harrow

Danishmand & Co.
Karakhana Bazar
Luallpur, Pakistan

Harrow

Ubungo Farm Implements
P.O. Box 2669
Dar Es Salaam, Tanzania

Singh Patela

This is a type of weeding harrow consisting of a 1.68-meter-wide wooden plank set in a steel frame and fitted with steel weeding hooks.

Rajasthan State Agro Industries Corp., Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006 Rajasthan, India

Soil Surgeon

This is an all-steel implement, 1.48 meter wide, with adjustable hooks which penetrate the soil to a depth of 100 millimeters and collect trash.

Rajasthan State Agro Industries Corp., Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006 Rajasthan, India

Spring-Tooth Harrow

This implement is suitable for tillage at depths to 150 millimeters (6 inches) and the action of the teeth loosens the soil. It is well suited to work in land which contains roots and stones. Depth of working is adjustable by a lever. Weight: 5-tine model, 40 kilograms; 7-tine model, 57 kilograms.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

Fixed-Tooth Harrows

No. of Sections	Working Width	Weight
1	0.70 m	27.5 kg
2	1.40 m	56 kg
3	2.10 m	82 kg

ETS. Techine
82400 Valence D'Agen
France

Blade Harrow

All-steel construction with depth and blade angle adjustments. Available in 225 and 450 millimeter sizes.

Rajasthan State Agro Industries Corp., Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006 Rajasthan, India

Adjustable Harrows

The angle of the teeth is adjustable by means of a lever fitted to each harrow section.

ETS. Techine
82400 Valence D'Agen
France

Bar Harrow

All-steel or wooden-framed models are available.

Danishmand & Co.
Karkhana Bazar
Lyallpur, Pakistan

Harrows

Various patterns of chain and spike harrows are available.

Samuel Lewis & Co., Ltd.
Northfield Rd., Netherton, Dudley
Worcestershire DY2 9JD, U.K.

Animal-Drawn Harrows

Each section has 15 teeth arranged in five rows. The section weighs 19 kilograms and its working width is 70 centimeters. One or two sections can be used at a time.

ETS. A. Bourguignon
B.P. 17
26300 Bourg-de-Peage
Drome, France

Safim-Tined Harrows

Triangular harrow weight		19 kg (42 lb.)
Diamond harrow weight	2-section	64 kg (140 lb.)
Diamond harrow weight	3-section	97 kg (214 lb.)
Diamond harrow weight	4-section	131 kg (289 lb.)
Zig Zag harrow weight	3-section	118 kg (259 lb.)
Zig Zag harrow weight	4-section	157 kg (345 lb.)

Massey-Ferguson (South Africa), Ltd.
Steel Rd., P.O. Box 677
Vereeniging 1930, South Africa

Aitkenhead Flexible Harrows

Four types of tooth link are available. These harrows are suitable for preparing seedbeds, covering seeds and fertilizers with soil, spreading farmyard manure, and killing weeds in growing corn.

William Aitkenhead, Ltd.
Stamford Works, Lees, Oldham
Lancashire OL4 3DF, U.K.

Lister Big-Claw Harrows

These flexible chain harrows can be rolled up and easily handled by one man, the sections being of 1.22 meter width. Various link types are available for use on arable land and grassland.

R.A. Lister Agricultural, Ltd.
Dursley
Gloucestershire GL11 4 HS, U.K.

Cultivators

Safim Expandable Cultivators

Model S51 is adjustable from 24 inches (610 millimeters) to 42 inches (1,067 millimeters) wide. It is fitted with two reversible shares in front, two reversible moldboard hillers, a 10-inch (254 millimeter) sweep at the rear, and two spare shovels. Weight: 44 kilograms (97 pounds).

Also available: Safim Mahon 5-tine expandable cultivator equipped with four 3-inch (76 millimeter) reversible points, two hillers and one 10-inch (250 millimeter) sweep. Weight: 44.5 kilograms (98 pounds).

Massey-Ferguson (South Africa), Ltd.
Steel Rd., P.O. Box 677
Vereeniging 1930, South Africa

Ox-Drawn Cultivator

Ubungo Farm Implements
P.O. Box 2669
Dar Es Salaam, Tanzania

Adjustable Cultivator or Horse Hoe

The five-tine cultivator is useful for preparing seedbeds after plowing.

Danishmand & Co.
Karkhana Bazar
Lyallpur, Pakistan

Occidental Hoe

This is an all-steel, ox-drawn hoe weighing 17 kilograms. It is fitted with a main beam and furrow wheel. A variety of hoe blades or cultivator tines can be clamped to the beam.

Siscoma
BP 3214
Dakar, Senegal

PLOWS

Safim CS2 Cultivator

This is an easily handled, all-steel cultivator for use with small draft animals. Two adjustable shovels, 5½ inches (140 millimeters) and 7 inches (178 millimeters), are standard equipment. Weight: 31 kilograms (68 pounds).

Massey-Ferguson (South Africa), Ltd.
Steel Rd., P.O. Box 677
Vereeniging 1930, South Africa

Soil-Stirring Plow

Mohinder & Co. Allied Industries
Kurali, Dist. Ropar
Punjab, India

Lever Expansion Cultivator

This five-tine cultivator is constructed of steel and can be adjusted from 300 millimeters to 635 millimeters width. It is fitted with hardened steel tines and an adjustable depth wheel.

Sharda Engineering Works
105/661 D, Fahimabad
Kanpur 208 005, India

Adjustable Hoe

The frame of this implement, which takes five hoe blades or cultivator tines, can be adjusted for row widths of 0.40 to 0.70 meters. Depth of work is adjusted by a lever controlling the depth wheel. Width adjustment is made by a screw mechanism. Weight: 45 kilograms.

A simplified version with width adjustment by means of a clamp on the frame is also available.

ETS. Techine
82400 Valence D'Agen
France

Triphali

An all-steel three-row implement for intercultivation.

Rajasthan State Agro Industries Corp., Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006 Rajasthan, India

Akola Hoe

This is a long-beam, three-tined cultivator which can be adjusted from 275 to 375 millimeters width.

Sharda Engineering Works
105/661 D, Fahimabad
Kanpur 208 005, India

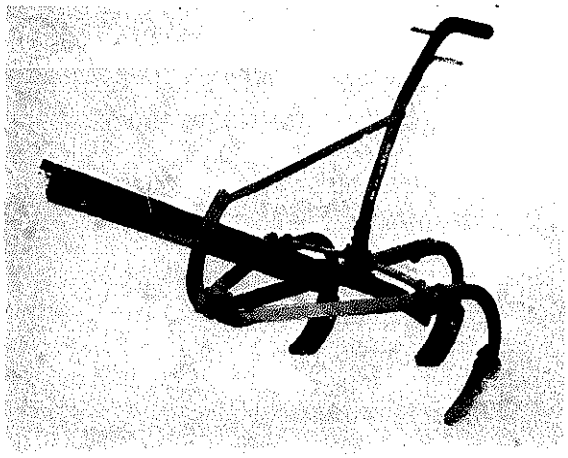
CeCoCo Animal-Drawn Cultivator

The working width of this cultivator can be easily adjusted and the blades remain parallel at all width settings. Weight: 21 kilograms.

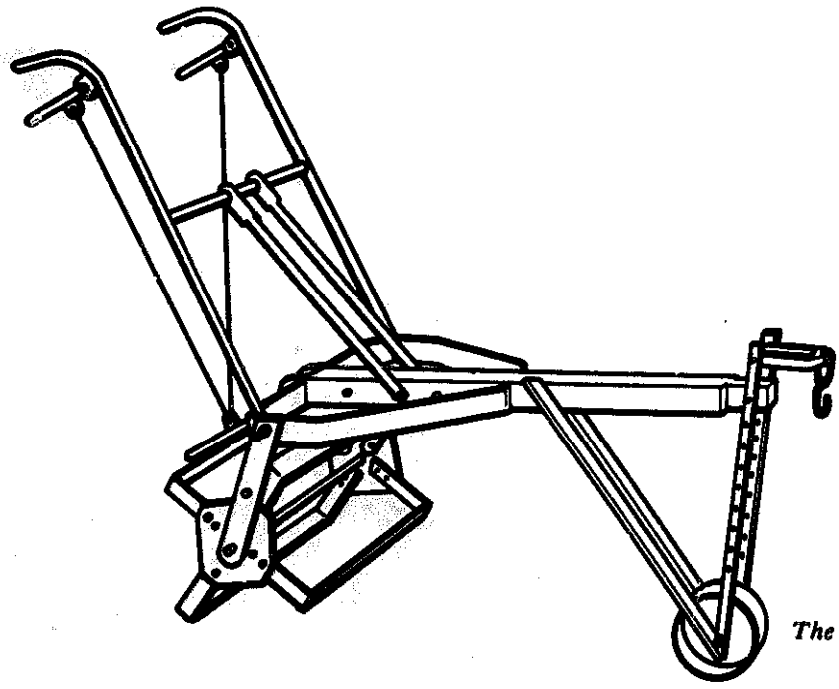
CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Cossul R.N. Cultivator

This is a three-tine cultivator, made of steel with long wooden beam and single handle. The shovels are made of high carbon steel and are reversible. The width can be adjusted very easily through holes provided in the frame. Depth can be adjusted by changing the height of the beam through holes provided for the purpose. Moldboard plow, ridger plow, and seeder/fertilizer attachment can be supplied as extras. Weight: 16.0 kilograms.



Cossul Bullock-Driven R.N. Cultivator
Cossul & Co.



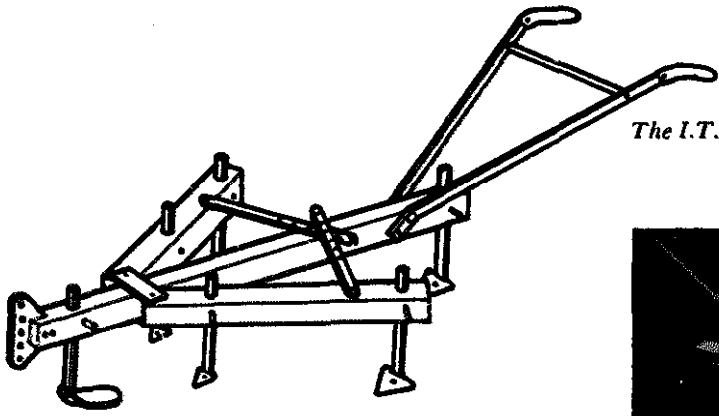
The I.I.S.R. Weeder-Mulcher

Cossul Lever Expansion Five-Tine Cultivator

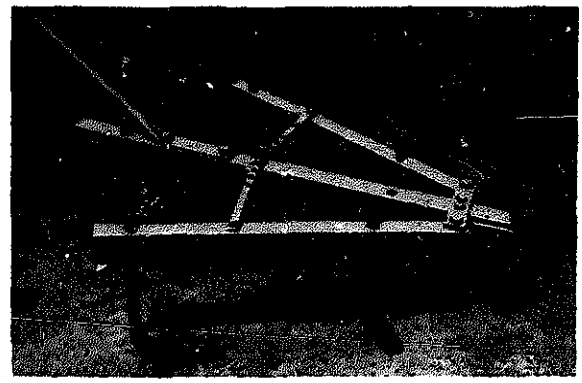
This cultivator is designed for preparing seedbeds and for inter-row cultivation. The points are reversible. The width can be adjusted from 300 to 625 millimeters (12 to 25 inches) by means of a lever. Right- and left-hand moldboards and rear double-face shovel are available as extras for throwing soil against the roots of growing plants and for making shallow channels for irrigation. Weight: 35 kilograms. Both above units manufactured by:
Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

The I.I.S.R. Weeder/Mulcher Plans (Indian Institute of Sugarcane Research)

This animal-drawn, self-cleaning weeder is designed to destroy weeds, leave a mulch on the soil surface, and cover a lot of area per day. It can be used on most row crops with a spacing of 30 inches (75 centimeters) or more. The blade works at a depth of 2 inches (5 centimeters) below the surface. The weed roots are cut or



The I.T.D.G. Expandable Cultivator



The first prototype model of the I.T.D.G. Expandable Cultivator

pulled out and the soil layer is lifted slightly. The weeds drop off the blade and soon dry out.

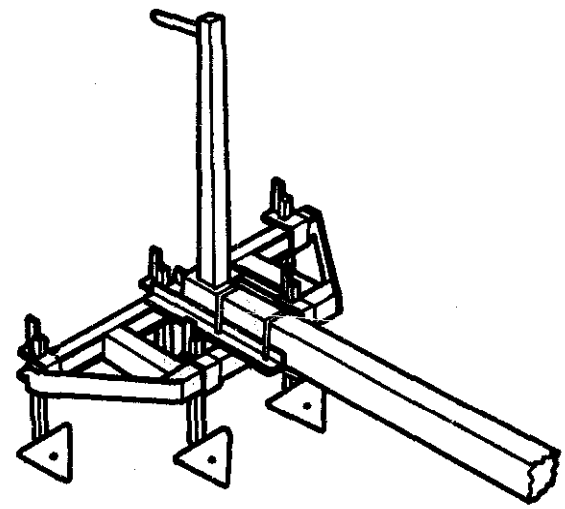
The Intermediate Technology Expandable Cultivator Plans

This lightweight cultivator is designed for weeding crops planted in 70 to 90-centimeter-spaced rows in sandy soils and can be pulled by one or two oxen or donkeys. The tines are individually adjustable for depth which makes the implement suitable for flat or ridge cultivation. The cultivator is suitable for manufacture by village blacksmiths.

The Indian Five-Tine Sweep Cultivator Plans

Dry farming areas where soil moisture conservation and soil erosion control are essential will benefit from this implement. The tool standards are staggered to allow crop residue and cut weed growth to remain on the soil surface. This cultivator can be used for primary tillage, seedbed preparation, weed control, and inter-row cultivation. The rigid steel frame can be built with additional toolbars to permit greater trash clearance.

Above three plans available from:
Intermediate Technology Publications, Ltd.
9 King St.
London WC2E 8HN, England



The Indian Five-Tine Sweep Cultivator

Manga Hoe

An adjustable-width cultivator available with 5 tines for donkey-draft or 7 tines for ox-draft. Extension bars are available to increase the width of the implement, in which form it can be used for row marking prior to planting.

S.A. Gard Pere et Fils
30500 Potelieres Par St. Amoroix (Gard)
France

Horse-Drawn Cultivator

Designed for spring cultivation following winter plowing, for cultivation of stubble, uprooting of quackgrass. Cultivating depth is controlled by a hand lever. Weight: 107 kilograms.

Agromet-Unia
Foreign Trade Enterprise
00-950 Przemyslowa 26
Warsaw, Poland

Multi-Purpose Potato Cultivator

Specially designed for potato cultivation, this combination three-purpose tool is supplied separately or combined with ridging, hoeing, and digging tools. The potato digger has a set of two guide wheels, the ridger, and an adjustable depth skid.

W. Hertecant
9200 Kwatrecht
Wetteren, Belgium

Miscellaneous Animal-Drawn Tools

Roller

This implement consists of two cylinders of 0.60 meters diameter. Available in two widths. Weight: 1.60-meter-wide model, 223 kilograms; 2.00-meter-wide model, 250 kilograms.

ETS. Techine
82400 Valance D'Agen
France

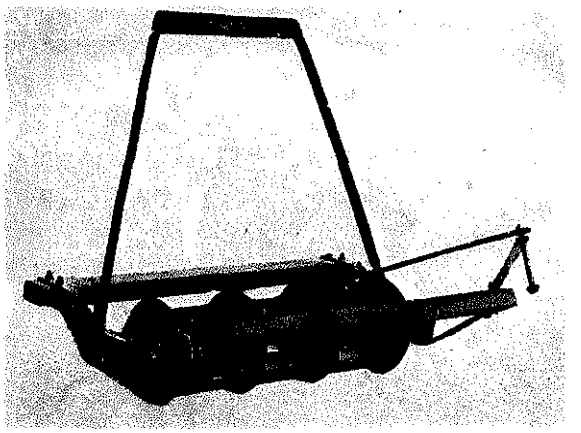
Wetland Puddler

It is designed for quick and efficient preparation of fields for paddy after first plowing. The three angular cast-iron hubs with four blades on each hub churn up the soil and leave the fine particles of it on the top surface. Weight: 39.5 kilograms.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

Cossul Bullock-Driven Green Manure Trampler

Growing a green manure crop and burying it is a way of adding to the organic matter content of the soil. This implement is useful for trampling green leaves and stalks. It consists of four 250-millimeter (10 inches) diameter steel discs with cast-iron hubs mounted on a horizontal shaft. Blades mounted on the shaft help to cut the green material. Weight: 39 kilograms.

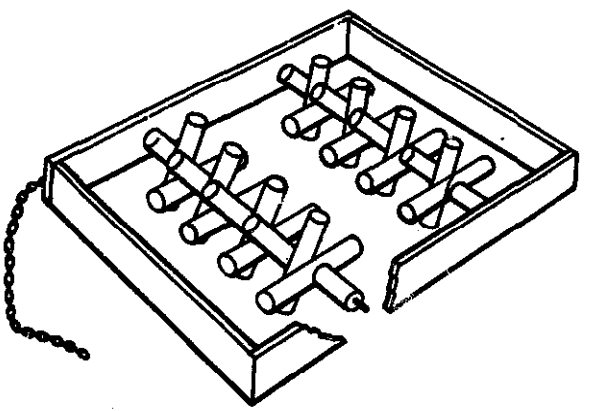


Cossul Green Manure Trampler
Cossul & Co.

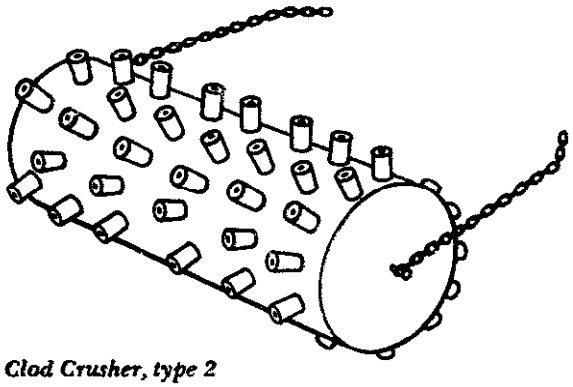
Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

I.T.D.G. Clod Crushers Plans

These are two simple and cheaply constructed implements which are used for reducing the size of clods in cultivated land prior to ridging up the soil. They are made principally of gum (eucalyptus) poles. Type 1 has roller gangs which are built from short pieces of pole



Clod Crusher, type 1

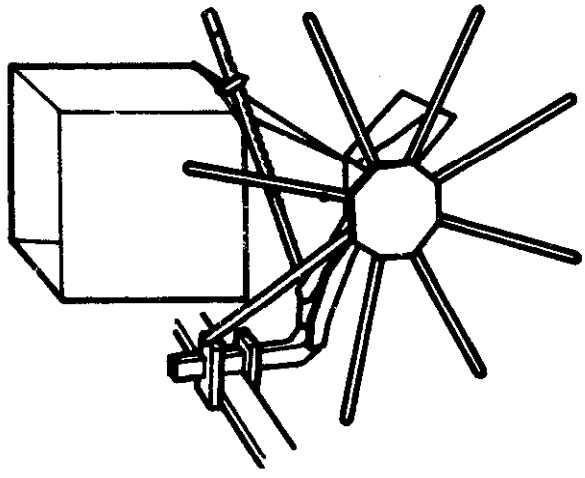


Clod Crusher, type 2

and rest at an angle of approximately 60 degrees to each other. The poles are mounted to provide a self-cleaning effect. Type 2 consists of short pole pegs attached in a staggered formation around the circumference of a single heavy log roller. Sharpened steel bolts are driven into the center of each end of the roller to which the draft chains are attached. A singletree is fitted to the roller chains.

I.T.D.G. Granule Applicator Plans

The granule applicator was developed as part of the Intermediate Technology Farm Equipment Development Project work program attached to the Institute of Agricultural Research of Ahmadu Bello University. A Planet Junior-based, hand-pushed seeder was fitted to an ariana toolbar and a simple direct-drive from a spiked wheel was used to replace the original bevel gears and shaft drive to the metering mechanism. Standard ariana soil-moving components were added to enable a ridge to be built and granules to be applied, either on the surface or incorporated into the soil, simultaneously.



I.T.D.G. Granule Applicator

Intermediate Technology Publications, Ltd.
9 King St.
London WC2E 8HN, England

-4- Tractors

TWO-WHEEL TRACTORS

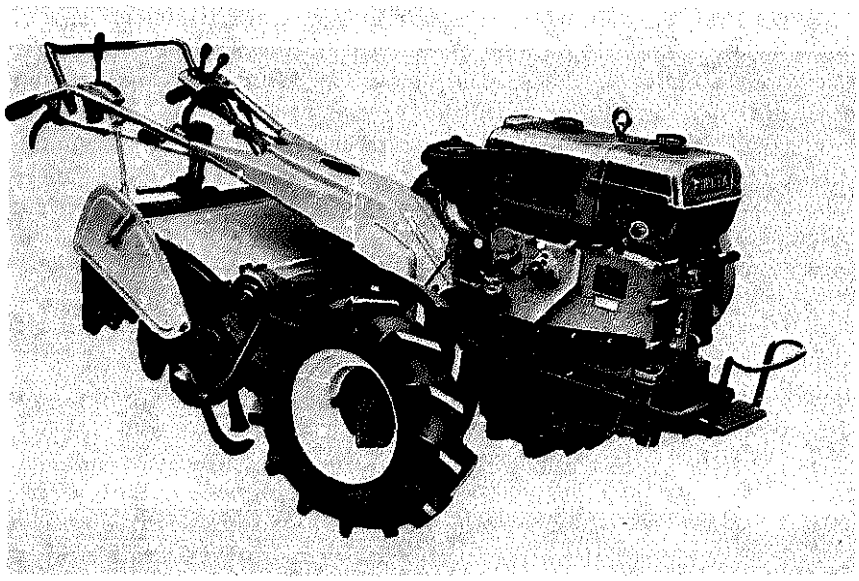
"Different levels of farm mechanization exist side by side in China," observes Ian Barwell in his report on the Chinese Two-Wheeled Tractor.* Barwell serves as a transport project officer with the Intermediate Technology Development Group based in London. He explains the different mechanization levels in terms of varying commune size (from 500 to 50,000 people), development, and farm machinery requirements. "At one and the same time, there is an increasing demand for conventional four-wheeled tractors, for two-wheeled tractors, and for draft animals such as horses and oxen for use in agricultural work."

Thousands of miles away, Gene Logsdon, an editor for *Organic Gardening* and *New Farm* in the United States, shows that a need for diversified, well-developed equipment is equally significant—even on a single, small farm such as his.

"When I figure my needs, I do not automatically figure that I have 20 acres to cultivate or even six, which is all the land I actually have in animal crops. Instead I look closely at that six-acre figure and ask myself: Of that total, how big an area will I ever have to plow (or disk, or weed, or plant, or harvest) in one day? The answer is usually one-quarter acre or less. That being the case, a quarter-acre is the size my tools need to be geared to."

"Actually, I'm overpowered with my ancient WD Allis-Chalmers tractor which has a horsepower rating of around 35. That's enough for quite a sizable little farm. My biggest plowing job takes me less than two hours. I only use my tractor's capability fully when I mow hay and pasturelands. My tractor would be just about right on an 80-acre farm if the 80 acres were devoted to the wide variety of food and fiber production typical of the self-sustaining homestead. Even on an 80, you should rarely *have* to work more than five acres a day. If, however, the entire 80 were given over to commercial fruit

* Material excerpted with permission from Ian J. Barwell. "The Chinese Two-Wheeled Tractor." *World Crops and Livestock,* July-August 1977.

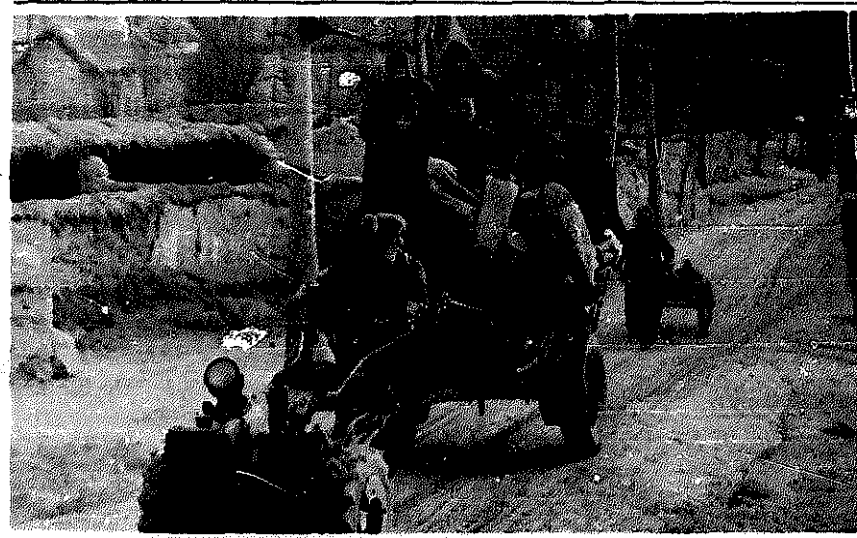


The Kubota, a Japanese two-wheeled tractor.
Kubota, Ltd.

and vegetable production or any single specialty crop, you would usually need quite larger machinery to handle it."

Just as Gene Logsdon in North America is firmly convinced that many growers should look at single-axle tractors and tillers, so, too, are the Chinese. The two-wheeled or single-axle tractor has played a vital role in the mechanization of Chinese agriculture, reports Ian Barwell. Since much of the cultivated land is divided into very small plots for irrigation, the two-wheeled tractor works well in such small land segments. Besides, the two-wheeled tractor is a much cheaper unit to buy and run than a conventional four-wheeled tractor, and it also lends itself to production by a number of small- and medium-scale factories throughout the country.

Writes Barwell, "Ease of maintenance and durability are major considerations in the design of the tractor which can be used for plowing or rotary cultivation, and as a power source to drive other items of machinery. Attached to a trailer, it forms a simple means of transport and is extensively used in this role, both in rural situations and to carry goods and people from the countryside to the town and back again. Current annual production of the tractor runs into hundreds of thousands of units, and they are now being exported to certain other developing countries; both India and the Philippines are now producing similar machines. However, the tractor is not suitable for use in the very dry conditions prevalent in parts of Africa, because it does not have the tractive power required for cultivation in such circumstances."



A single-axle tractor hitched to a two-wheeled trailer for transport.
Ian Barwell

The tractor engine, he reports, has a power output of ten horsepower. The heart of the two-wheeled tractor is its rugged and durable single-cylinder, four-stroke diesel engine. Barwell continues:

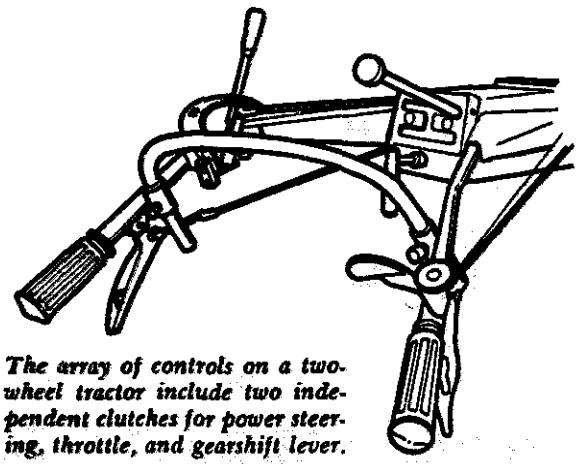
"The engine, whose main block and crankcase are a single iron casting, has two other interesting features which simplify maintenance. It is water-cooled by means of an evaporative tank system mounted above the block. It is this feature which is responsible for the characteristic wisp of steam rising from the tractor when it is in use. Direct visual indication of the water level is achieved by means of a red button mounted on the end of a rod protruding from the tank and attached inside to a float. As the water evaporates, the rod falls until the danger level is reached, and the button drops out of sight of the tractor operator. A forced-circulation, oil lubrication system is used, and the oil is passed through a sight glass visible to the operator so that he has a continuous check on the flow of lubricant."

The Chinese have many uses for the two-wheeled tractor. It can be fitted with either a single- or a two-furrow plow which attaches to a bracket at the rear of the gearbox. The setting of the plow can be adjusted for height, for angle relative to the direction of travel, and for orien-

tation of the blades themselves. The tractor can plow to a depth of 180 to 200 millimeters.

Using the power take-off at the rear of the gearbox, a rotary cultivator fitted with up to 16 blades can be attached. The rotor is shrouded by a canopy which helps to break up the lumps of earth, and the depth of cultivation is controlled by either a skid or a small-diameter wheel mounted behind the cultivator.

When plowing or cultivating, the operator may either walk along behind the tractor or sit on a seat mounted at the very rear of the machine. Steering is effected by control of the clutches engaging the drive to each of the wheels. The tractor is reportedly capable of working 0.1 to 0.15 hectares per hour.



The array of controls on a two-wheel tractor include two independent clutches for power steering, throttle, and gearshift lever.

The tractor can be driven to and from the fields if a small castor wheel is fitted at the rear. However, when it is used for cargo or passenger transport the tractor is hitched to a two-wheeled trailer, and the driver normally sits on a seat at the front of the trailer. He can then steer the vehicle by means of the handlebar, and this obviates the need for the castor wheel. Maximum payload in the transport mode averages 1,200 kilograms.

Mounted on the end of the crankshaft alongside the grooved pulley described earlier is a large flywheel which doubles as a flat-topped pulley. Using this feature, the tractor may be used as a source of power to drive a range of items of agricultural and crop-processing equipment, through a flat-belt drive system. It could, for example, be used to power a water pump, an electricity generator, a flour mill, or a rice thresher.

SINGLE-AXLE TILLERS AND TRACTORS

A great variety of single-axle, sometimes called two-wheel, walking, or pedestrian tractors is available. The smaller models generally have a single-driven shaft which can be fitted either with rotary cultivator blades or with wheels for pulling trailers and trailed implements. Larger models often have a pair of driving wheels and an independently controlled drive for rotary cultivating. Engines usually run on gasoline in the smaller sizes and use diesel fuel in larger sizes. Transmission systems range from V-belt drive (with speed changing by means of stepped pulleys, and belt tensioning providing a clutch) to multispeed gear transmission with friction plate clutches.

Most manufacturers can supply a range of attachments for cultivation and transport work, and water pumps can usually be fitted, although it should be remembered that pumping is generally an arduous duty for a small engine. One maker supplies a threshing attachment with a rasp, bar-type drum, and concave.

Single-axle tractors have sometimes proved to be very successful in intensive agriculture on relatively soft soils which need thorough rotary cultivation—for example, in irrigated rice paddies in Asia or on market-gardening plots in Europe. They have been much less successful for relatively extensive agriculture on hard soils such as those in some savannah regions of Africa, where large areas have to be covered and tined cultivation is often more appropriate than rotary cultivation.

Like all small-engine-powered equipment, single-axle tractors require a good network of spare-part supplies, a high level of operator training, and regular maintenance, particularly in hot and/or dusty working conditions.

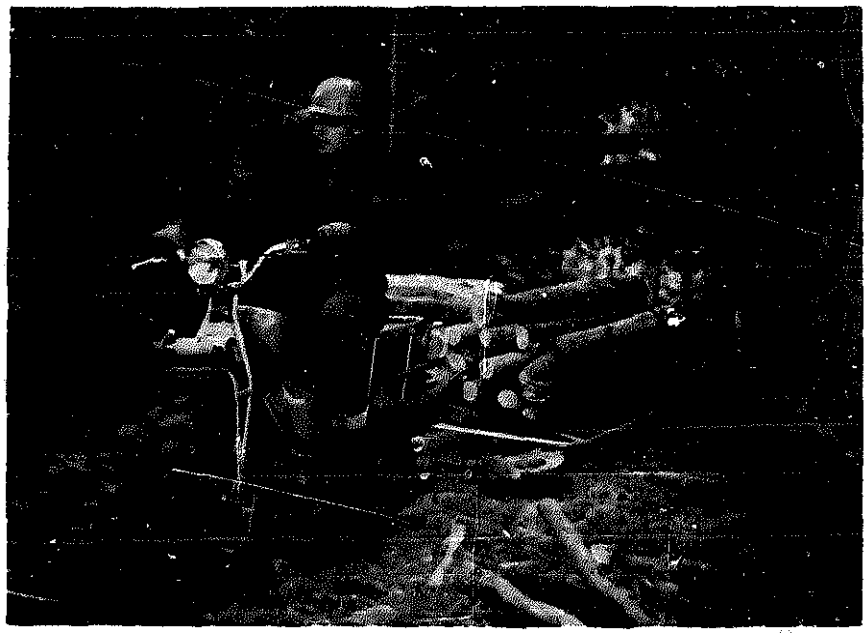
NORTH AMERICAN SOURCES OF WALKING TRACTORS

The Rokon Automatic Mototractor

At first glance, one can hardly take this stocky trail bike seriously as a useful farm implement. But after serious study, it is obvious that

the Mototractor is a two-wheeled, two-wheel drive, dual-purpose power unit designed to handle all the usual farm chores with the same hearty determination of any tractor—while providing an expedient, rugged means of transportation as well.

A conversation with a Technical Assistance Official for Africa revealed that "the Mototractor could well be the sole piece of technology developed in the United States with significant implications for emerging nations. It is extremely strong and has few moving parts. In order to be useful, a farm tool must be able to till more land than the space it needs to turn around in, a problem with Western-oriented equipment.

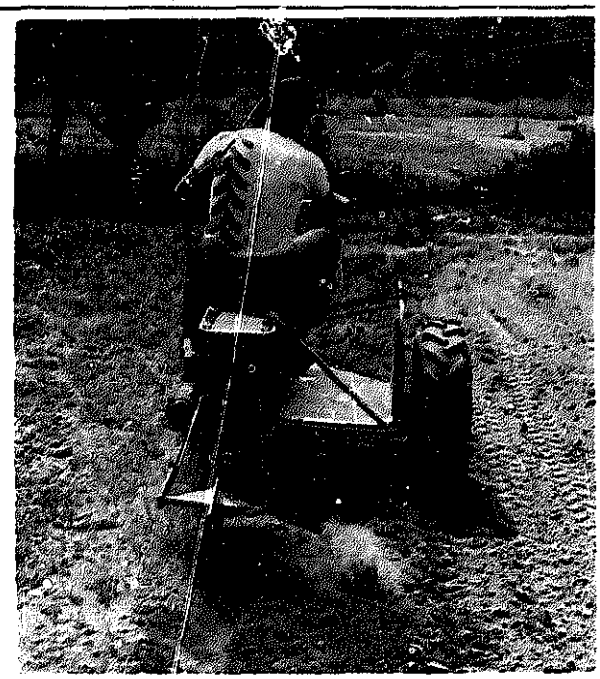


The Rokon tractor crosses rugged terrain towing a heavy load.
Rokon, Inc.

"Unlike Far Eastern countries, labor is at a premium in Africa, not land. Without the help of a labor force, the farmer must rely on mechanization to get enough land prepared to feed his family and provide him with a cash crop. At the same time, he needs a means of local transportation and a way to get his produce to market—especially during the rainy season."

Rokon has designed the Mototractor to satisfy both needs. It has all the attachments of a small-farm, utility tractor—plow, cultivators, trailer, and spraying and irrigating equipment—is able to transverse two-foot streams, has wide tires for superior traction in mud, has a ten-horsepower gasoline engine and power take-off shaft, can climb 45-degree inclines, and has a maximum operating speed of 40 miles per hour.

In the United States, the Mototractor is widely used by engineers, foresters, and fire-



A third wheel provides added balance for plowing at slow speeds. Rokon, Inc.

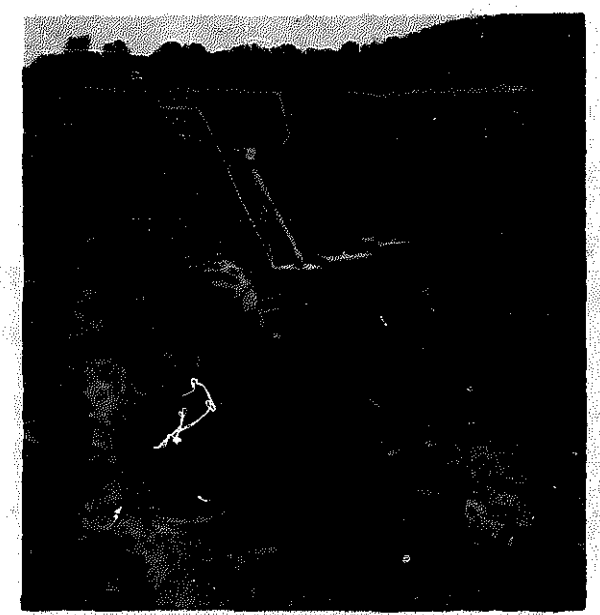
fighters for rapid travel over rough terrain. The power take-off shaft will operate a pump for fire-fighting as well as many farm tools. Gearing ratios provide pulling power which has proved valuable in rescue operations. One ski resort in Vermont uses their Mototractor to climb mountains carrying workers, tools, and materials all year-round, as well as for rescue.

Rokon, Inc.
American Engineers & Manufacturers
160 Emerald St.
Keene, NH 03431

THE FORD DNT PEDESTRIAN TRACTOR, NOW THE INTEC

In 1964, Ford decided to develop a program designed to help solve the world food crisis while enhancing the reputation of the company and its farm products in developing nations. After a series of conferences with university and foundation experts and with representatives of governmental agencies, "Ford elected to design a tractor which would provide simple mechanization for small farmers at a price roughly comparable to a pair of oxen," reports Richard Dewey, Public Relations Manager for Ford Tractor Operations.

After five years of research and engineering Ford was ready to test marketability of their new model DNT—*D*eveloping *N*ations *T*ractor. Confidence in its powerful, reliable transaxle system, wheels designed for added strength and improved traction, the simplicity of the rope starter and push-pull metal clutch rod, and its basic rugged, durable design encouraged them to continue. As their news release announced, "The two-wheeled tractor is the first ever designed specifically to bring the benefits of modern farming technology to people on small farms in developing countries at a price they can afford to pay."



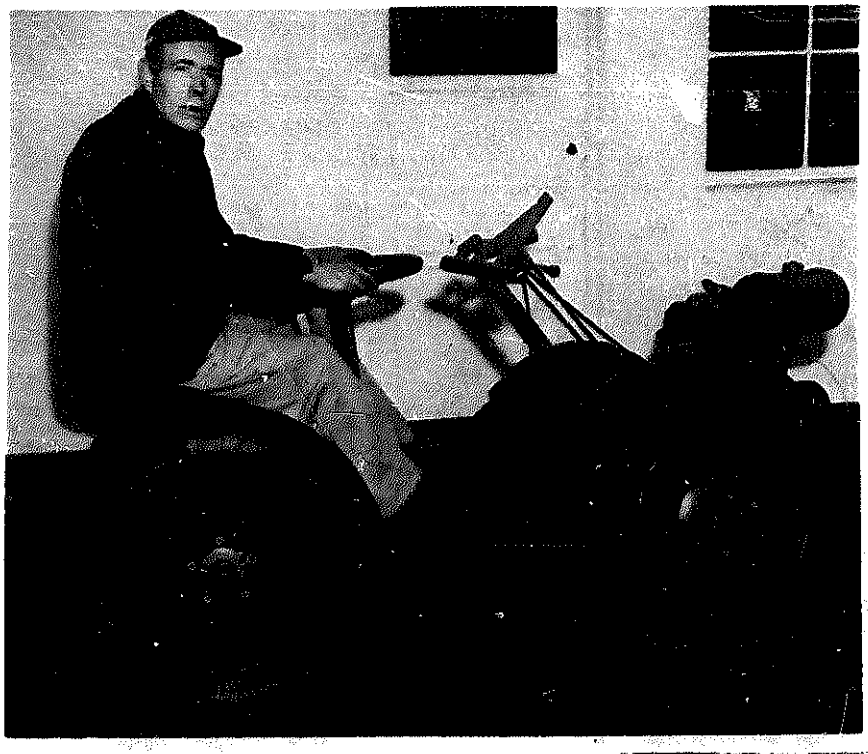
The INTEC's high ground clearance is an important feature in continuing mechanical cultivation late into the season.
Dowding Tool Products, Inc.

But "insurmountable logistical and social problems" terminated the effort. Dewey continued, "Getting spare parts to dealers posed no difficulty but getting the dealer to the broken-down machinery did. It just wouldn't pay any serviceman to spend three or four days trekking through the jungle in search of his customer. With attitudes as stubborn as they are, it's hard to convince village farmers that anything new, even appropriately scaled and designed machinery, will do the job right. They are skeptical of a tractor which runs on hard-to-get fuel and eventually breaks down into a pile of rusty nuts and bolts. Fuel for animals grows on trees and a worn-out ox can be eaten. There's real 'horse sense' in using animal-drawn equipment in developing countries."

BUILD—'EM—YOURSELF TWO- AND FOUR-WHEELED TRACTORS

Paul Davenport started building tractors over twenty years ago from parts he scrounged mostly from old Model A Fords. Now he says he is too old for that kind of work, but he still sells the plans for a two-wheel model with a two-and-one-half- or six-horsepower motor, and a four-wheeled, four-wheel-drive, six-horsepower model.

The feature Paul boasts of most is the ruggedness of his tractors. "These parts were originally designed to take the power of a 24-horsepower engine. With these small engines, they will last almost indefinitely." Some parts include a standard Model A transmission with three forward speeds and reverse, brakes for turning and handling, and regular wheels and tires (or implement tires).



You can build this four-wheeled, four-wheel-drive tractor from a Davenport kit.
Paul Davenport



The Davenport two-wheel tractor has a drawbar with a single pin for changing implements quickly.
Paul Davenport

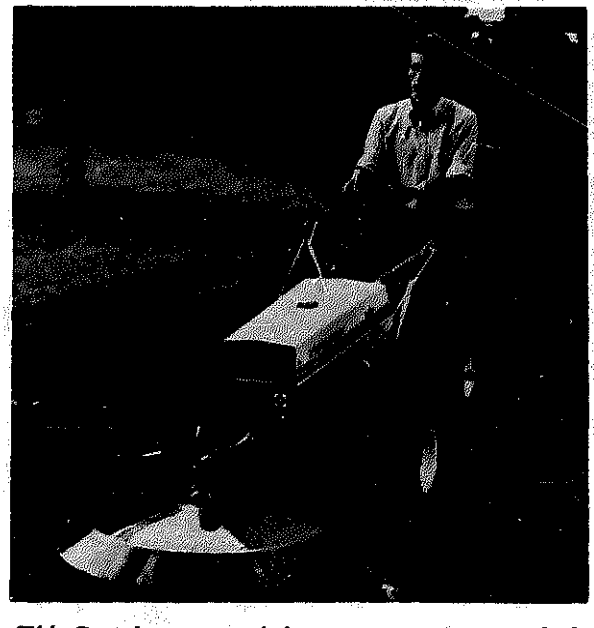
The actual building cost is hard to estimate. It all depends upon how good a scrounger you are and how much of the work you can do for yourself. There is a certain amount of cutting, drilling, and welding you will need to do, or perhaps your local welder will have to help you out.

The plans illustrate a simple but practical drawbar which pulls from ahead of the axles for better handling. A single pin allows a quick change of implements. With the two-and-one-half-horsepower engine on his two-wheeled tractor, Paul can pull a nine-inch plow, eight inches deep in low gear. The four-wheeled unit can pull a 12-inch plow ten inches deep in light to medium soil. Flexibility in the center, keeping all four wheels on the ground, regardless of terrain, coupled with four-wheel drive gives this machine "sensational pulling power."

Paul's Tractor Co.
8520 Cherry St.
Fontana, CA 92335

Gravely Convertible Tractors

Gravely Convertible two-wheel tractors have an all-gear transmission separately powering both the wheels and the power take-off shaft for attachments. Models with 8, 10, and 12 h.p. engines provide power to match the job requirements and operate with forward, neutral, and reverse speeds. Attachments include sickle bar; rotary and flail mowers; a plow, sweeper, and blower for snow; a dumping trailer; and, for the garden, a furrower, cultivator, shovel, and rotary tiller.

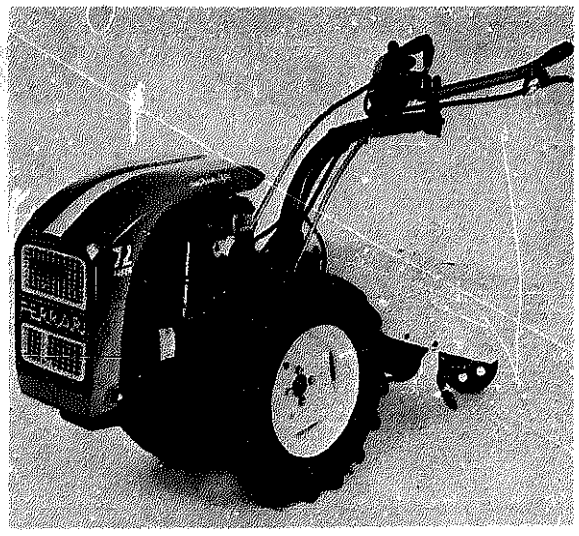


This Gravely power unit has a rotary mower attached to the front, dual wheels for better traction, and a riding sulky with steering column.
Clarke-Gravely Corp.

Gravely Division of Clark-Gravely Corp.
One Gravely Lane
Clemmons, NC 27012

Ferrari

Ferrari carries three models of walking tractors with air-cooled diesel engines ranging from 7 to 21 h.p. The fuel injection system means there are no plugs, points, magneto, or carburetor. Direct gear-drive replaces the need for chains or belts. The middle range, 14 h.p. model has four forward and two reverse speeds, and power take-offs, each with two speeds. The tilling width is about 30 inches and the unit readily accommodates a sickle bar, snow blower, trailer, sprayer, plows, and even a table saw.



Ferrari with tiller attachment
Ferrari International, Inc.

Ferrari International, Inc.
6104 Avenida Encinas
Carlsbad, CA 92008

Ferrari S.P.A. Officine Meccaniche
42045 Luzzara
Reggio Emilia, Italy

Pasquali Walking Tractors

Pasquali Italian-made walking tractors come in many sizes, ranging from 7 to 18 h.p. All are equipped with a four-stroke, air-cooled diesel engine. The lower-powered models, from 7 to 14 h.p., have four speeds forward and two reverse; the higher-powered units have a sliding-type key gear with synchronizer operating twelve speeds—nine forward, three reverse—at a rate of 0.6 to 16 kph. All models have two power take-off shafts, the top one synchronized with all gearbox speeds and the bottom one with two independent speeds. The rotary tiller disconnects automatically when reverse gear is engaged, and the handles are completely adjustable.

Pasquali has the unusual attraction of offering over 70 attachments for its walking tractors. So extensive is their list of attachments that it takes a 200-page book to describe them all. All are available upon request through a dealer in the United States with the allowance of a twelve-week lead time.



The Pasquali Model 946
Pasquali U.S.A.

Pasquali USA
Verona, WI 53593

Pasquali: Macchine Agricole s.p.a.
Via Nuova, 30
Calenzano (Firenze)
Pama Calenzano, Italy

EDKO Walking Tractor

The EDKO tractor is constructed with a ¼-inch by 3-inch frame and 11-gauge handle with three-position adjustment. It is powered by a 5 h.p. gasoline engine with six-to-one gear reduction and recoil starter. It features two speeds forward with "dead man" reverse (1.25 mph). Low speed ranges from 1 to 1.75 mph, high speed from 2 to 2.75. It has a rugged chain-drive system with dual-split steel pulleys, and 11-inch ground clearance axle with rachet wheel. Wheel widths are adjustable from 17 to 23 inches on



The EDKO Chain-Drive Walking Tractor with toolbar and cultivators.
EDKO Mfg., Inc.

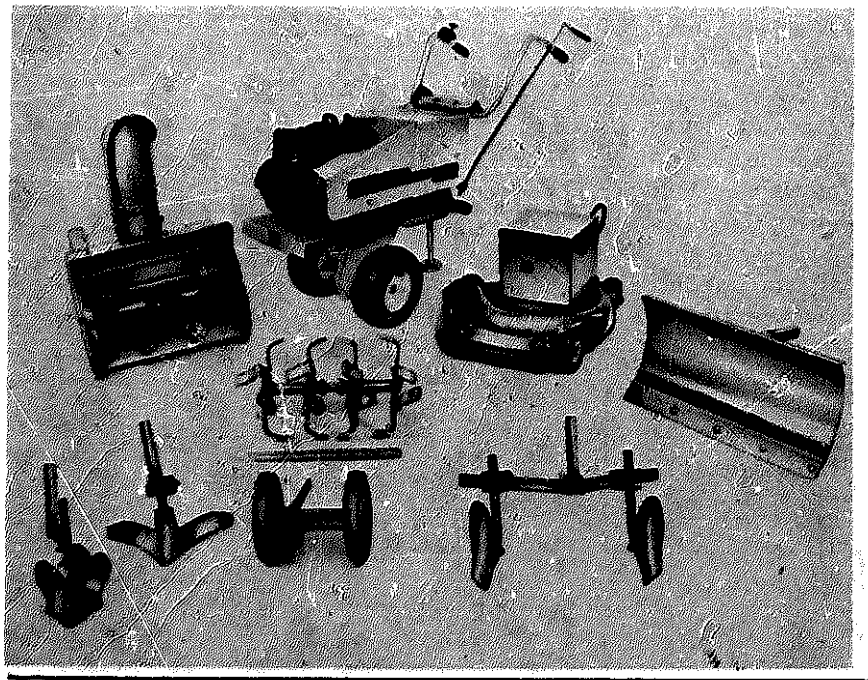
1-inch increments for each wheel. No tools are required to change the following attachments: 7-inch moldboard plow with coulter, disc, six-prong cultivator, furrow opener, 40-inch blade, wheel weights, and chains.

EDKO Mfg., Inc.
2725 Second Ave.
Des Moines, IA 50313

Haban Power-Trac V

The chain-drive transmission with one speed forward and reverse is provided only in the 5 h.p. size. The 3 h.p. model has no reverse. An attachment clutch acts independently of traction controls. Controls are mounted on handlebars of tubular steel. It has semipneumatic tires with 11-inch by 4:00 wheels. Both models feature 14-inch tines for tilling a patch 26 inches wide and 8 inches or more deep. Attachments for the 5 h.p. model include a variety of cultivator tools, a 22-inch-cut rotary mower, a 24-inch snow-thrower, and a 30-inch dozer blade for grading gravel and clearing snow.

Haban Mfg. Co.
2100 Northwestern Ave.
Racine, WI 53404



The Haban Power-Trac V with attachments: snow-blower, rotary mower, scraper blade, bolo tiller tines and depth bar, furrower, sweep, rubber tires, and hiller.
Haban Mfg. Co.

INTERNATIONAL SOURCES OF WALKING TRACTORS

Bucher M600

The Bucher M600 cutter bar mowers are specifically designed walking tractors for mowing and windrowing crops grown on the steep slopes of Switzerland. Three different mechanisms are available for windrowing; a trailer and sulky are also available. Special wheel extensions keep the mower upright when traversing a slope. The M600 is run by a 10 h.p., air-cooled gasoline engine, has three forward, one reverse speed, and weighs 320 kilograms. Other models are available ranging from 7 to 11 horsepower. At this writing, Bucher-Guyer is seeking a North American distributor.

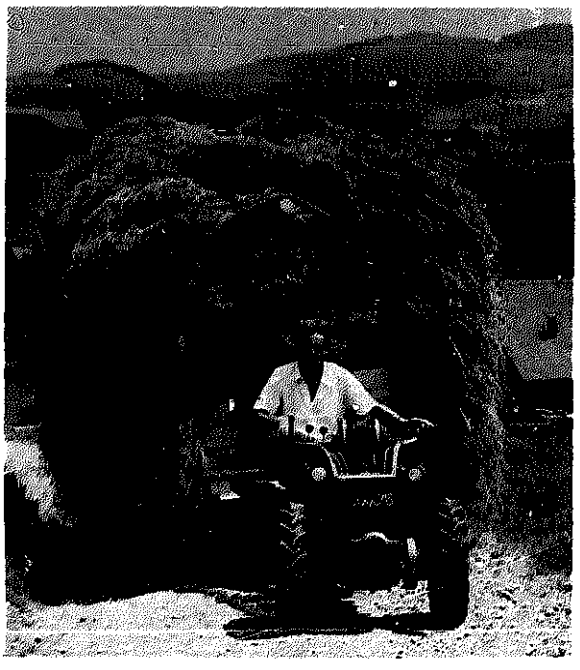
Bucher-Guyer, Ltd. Engineering Works
CH-8166 Niederweningen
Zurich, Switzerland

AEBI AM Walking Tractors

AEBI tractors come in three models: the AM 8; the AM 15, with 15 h.p.; and the AM 75, with 10 h.p. All have four-stroke gasoline engines and mowing attachments. The AM 75 has a transmission with four forward and one reverse speed,



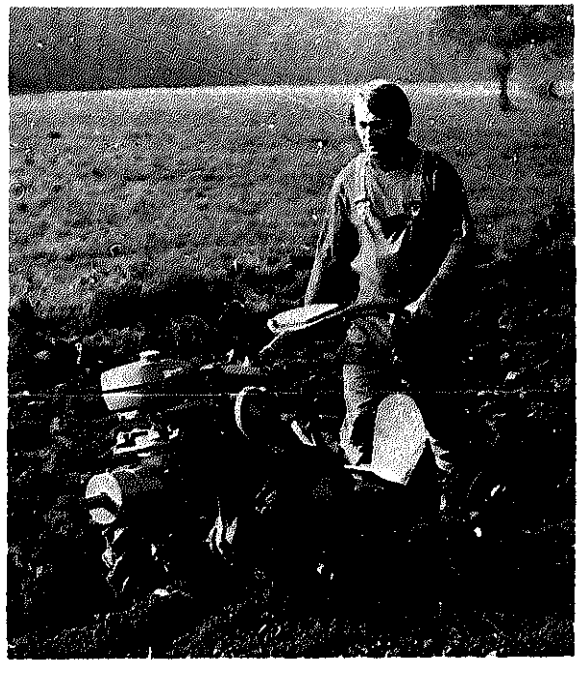
Bucher Cutter Bar Mower M200
Bucher-Guyer, Ltd. Engineering Works



The AEBI AM75 pulling quite a load uphill.
AEBI & Co.

a high-/low-speed option for the cutter bar and three forward and one reverse speed for the rear power take-off. Power can be linked to a trailer capable of a 900-kilogram payload; hence the unit becomes a four-wheel-drive machine. Other attachments include a sulky, hay turner, and rotary tiller. Operating in reverse, the AEBI AM 75 pulls a potato harvester which digs the potatoes, sifts the soil away from the tubers, and deposits them in a row on the surface of the soil.

AEBI & Co.
AG Maschinenfabrik
CH-3400 Burgdorf, Switzerland



Agria 6000 with weighted wheels for extra traction to pull a reversible moldboard plow.
Agria-Werke

Agria Model 2400 Walking Tractor

Agria Model 2400 walking tractors are available with either an 8 h.p., two-stroke or a 9 h.p., four-stroke gasoline engine. They have a six-speed gearbox, three forward and three reverse, and an independent power take-off shaft. The steel-tube handlebars are adjustable 180 degrees, and track width can be adjusted from 10.6 to 22.2 inches, depending upon accessories and row width. A wide range of attachments makes this unit Agria's versatile one. Attachments include a two-section, adjustable harrow, a two-piston spray pump, a water pump, a 31.5-inch spindle reel mower with seat, snow blower and plow, sweeper, rotary tillers with widths between 12.6 and 26 inches with or without duckfoot hoe, quarter-turn plow, reversible plow, ridger, cultivator, mulcher, sickle bar mowers of different working widths and fineness cuts, and a trailer with seat.

Agria Model 2700

Designed for power rather than versatility, the robust Agria 2700 walking tractor has a 13-h.p., four-stroke diesel engine with electric start. The nine-speed gearbox, six forward and three reverse, operates at rates between 0.7 and 12 mph. The upper power take-off shaft operates at two speeds; the bottom also at two but with the option of operating independently of the gearbox. The lower shaft stops automatically when reverse gear is engaged. The 270-kilogram unit is balanced for easy maneuverability when hoeing, tilling, plowing, and transporting. One unusual attachment is the sprinkler, complete with water tank. Agria is not represented in North America at this time and is seeking distributors.



Robust Agria 2700 with rotary tiller
Agria-Werke

Agria-Werke GmbH
D-7108 Moeckmuehl
West Germany

Moty Mule Universal

The Mule is a versatile mowing, tilling, hay-harvesting implement built for safe operation on steep slopes. It is available with either a two- or four-cycle gasoline engine or a four-cycle diesel engine. A floating axle adapts to rough ground conditions without transmitting jolts to the operator. The V-belt power transmission absorbs the shock when obstacles jam the cutting blade on the reciprocating mower. Front and rear power take-off shafts are provided to power a great variety of implement attachments which may be installed in seconds, thanks to a quick-disconnect arrangement. The rear power take-off can also be utilized to propel the shaft for a wheel-drive trailer. The unit weighs 150 kilograms, 100 kilograms without the mowing attachment, and operates in first gear at 4 kph, second gear at 10 kph and reverse at 3 kph. More than 25 attachments are available. Some of the more unusual ones include a grain-reaping attachment, push-on grinding attachment, hay-pushing rake, dibbling seeder with two-row arrangement, hay rake and tedder, hay rake with reversible rotation arrangement, and vineyard plow.

Moty-Werk, Landmachinenbau
8523 Frauental A./L62
Austria/Stmk

Kubota Versatiller

A heavy unit weighing 485 kilograms, the Kubota Versatiller has a continuous output of 9 h.p. and a maximum of 12. It operates at six

forward and two reverse speeds and the tilling unit operates at four speeds. With a maximum traveling speed of 15 kph, the unit is powered by a rotary, diesel-powered, water-cooled engine with radiator. It tills a width of 60 centimeters, a depth of 19 centimeters with 20 blades, tilling at a rate of 1 hectare every ten hours. The Kubota puddles wet fields, tills, plows, harrows, and weeds. The power take-off provides a stationary 12-h.p. engine to drive belt-driven machines such as threshers, hullers, and generators.

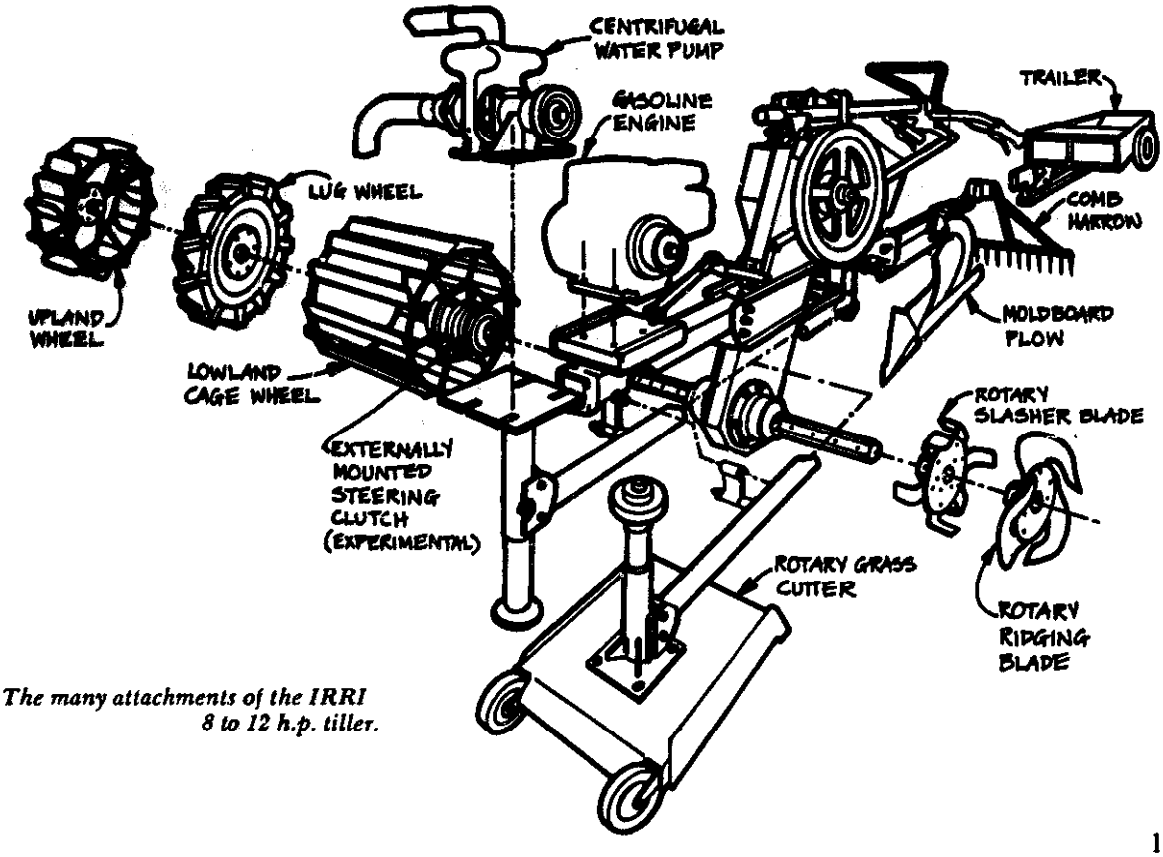
Kerala Agro-Machinery Corp., Ltd.
Athani P.O. Ernakulam District
Kerala, India

Kubota, Ltd.
22 Funade-cho
2-chome Naniwa-ku
Osaka, Japan

Note: The Kerala Corporation is interested in marketing their products in North America but has no distributor at this time.

IRRI Power Tiller

The International Rice Research Institute has designed this 8 to 12 h.p. tiller with features especially for developing countries. The heavy-duty power tiller offers almost all of the features of the latest power tillers produced in the industrialized countries, yet it can be easily fabricated in developing nations at a fraction of the cost. The machine is well balanced and is equipped with steering clutches for easy maneuverability. The four forward and two reverse speeds can be shifted by using a simple main clutch control and gear shifting lever. Belts do not have to be shifted to change speeds. Used for cultivation on both upland and lowland conditions, the tiller can prepare 1.2 to 1.5 hectares of land per eight-hour day and can transport 600 kilograms on country roads. This rigid, heavy-duty machine is equipped with a water-cooled, horizontal-stroke diesel engine which transfers power through V-belts. Maintenance cost is kept low as most parts can be easily repaired in small machine shops, and many machine elements are readily available to developing nations.



The many attachments of the IRRI 8 to 12 h.p. tiller.



The IRRI Power Tiller is seen here puddling a rice paddy while pulling the operator on a puddling sled. Notice the weight extending to the front to compensate for the weight of the sled and operator.
International Rice Research Institute



Not yet widely adopted, the IRRI puddling sled can be modified for construction with local materials for less than $20.
International Rice Research Institute

Simple to manufacture, the power tiller has five major assemblies: engine, transfer case, multispeed gear transmission, handlebars, and rotary tiller. All components, except the engine, can be easily fabricated in developing nations without special production dies and tooling. Consequently, production can be economical even with low market demand.

Manufacturers' addresses and construction plans are available from:
Agricultural Engineering Department
International Rice Research Institute
P.O. Box 933
Manila, Philippines

Hakorette Standard

The Hakorette comes with a 6 h.p. two-stroke engine, elastic three-stage V-belt drive transmission with three speeds up to 10 mph. High-traction capacity powers attachments which include rotovator, snowplow, trailer with 500-kilogram or ½-ton capacity, 8-inch plow, and a reel mower with seat.

Hako-Werke
2060 Bad Oldesloe
Postfach 1444, West Germany

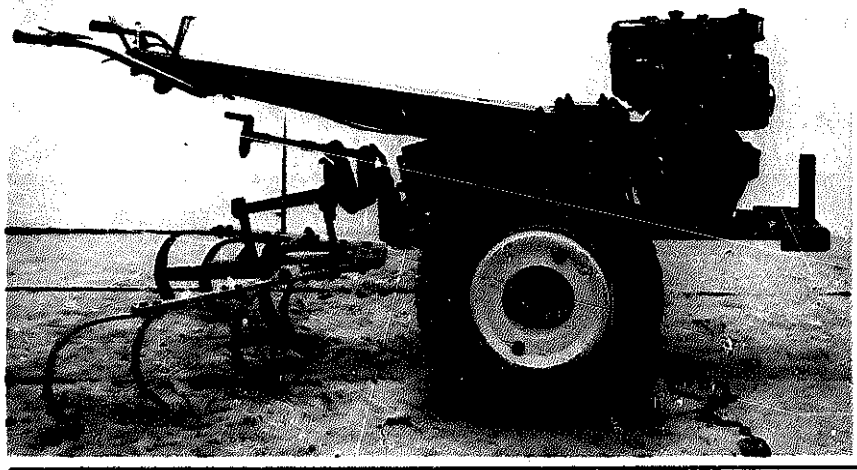
Solo

The Solo combi-system is a single 4 h.p., two-stroke engine complete with centrifugal clutch which can be fitted quickly to any of the following implements: mower, rotary cultivator, generator, earth auger, water pump, or outboard motor.

Solo Kleinmotoren GmbH
7032 Sindelfingen 6
Postfach 20, West Germany

Bouyer Two-Wheel Tropical Tractors

Though they are made in France, these tractors are marketed solely (at present) in developing nations. They were designed in collaboration with CEEMAT (Center for Studies and Tests of Tropical Material), specifically to satisfy the demands of tropical cotton culture following a request of the CFDT (French Company of Textile). A spokesman for Bouyer explained, "It appeared to this company that a normal tractor was not able to work in cotton fields. In fact, it requires a simple machine to make eventual repairs very easy in areas far from economic centers, and a specific machine for cotton with a high clearance and an adjustable working width." They are able to work both in wet and dry cultures under hot climates.



Bouyer Walking Tractor with cultivator attachment. Notice depth adjustment and handlebar controls. Wheel weights are mounted to improve traction, and the extending frame in the front is a provision for adding even more weight.
Bouyer

Type 203

This is the smallest tractor made by Bouyer. It has a 5 h.p., four-stroke, air-cooled gasoline engine. The gearbox houses two speed ranges with two forward speeds each and two reverse speeds. There are two speeds for the power take-off shaft.

Type 334

Powered by a 6 or 7 h.p., four-stroke gasoline or diesel air-cooled engine, it has two ranges of three forward speeds and one range of three reverse speeds. There is one speed for the power take-off shaft.

Type TR

The heftiest of the Bouyer products has a four-stroke, air-cooled diesel engine available in either 9, 11 or 14 h.p. Special features for operation in a hot climate include an oil regenerator and oil bath air filter. There are two speed ranges for three forward speeds and one range of three reverse speeds. Three power take-off shafts operate at different speeds including one independent, one independent with clutch, and one driving the rotovator.

Bouyer supplies a wide range of attachments for use with all three tractors, though sizes differ. These include many variations of plows such as a reversible plow, universal hitch, rotovator, cultivators, toolbar frame for carrying hoes, potato lifter, four-row seeding drill, two-row drill seeder and fertilizer combination, spraying equipment and trailer reservoir, irrigation pump, sickle bar and rear rotary mowers-disc harrows, and many wheels for better traction in both wet and dry cultures. At the time of this writing, Bouyer is interested in establishing a distributor in North America.

Bouyer
B.P. 23
Tomblaine 54510, France

Sagisag Model A by Mametora

Any engine of a farmer's choice can be mounted on the basic engine frame. An overdrive clutch mechanism provides transmission efficiency when changing the all-gear transmission with 12 forward and six reverse speeds. Electric start and headlight are provided. The 16-blade rotary tiller tills 13 centimeters deep and 60 centimeters wide. The manufacturer claims a capacity of 2 hectares per hour with tiller; the plow attachment takes 75 minutes to cover the same area.

Tramat Mercantile, Inc.
747-749 Gandara St.
Sta. Cruz, Manila

Mametora Power Tillers MC

Three models are available from this company, no horsepower ratings are given. All have four-cycle, vertical, monocylinder engines with air cooling, two power take-off shafts, V-belt and gear-driven transmission with two forward and one reverse speed.

Mametora Power Tiller HMD

A 7 h.p. unit has all-gear transmission, eight speeds forward, four reverse and a four-cycle, 252-cubic centimeter engine. Attachments include a rotary plow, side and middle furrower, puddling wheel and rakes, power transmission pulley, and trailer.

Other models are available.

Mametora Return-Culti

The Return-Culti is the largest of the many walking tillers Mametora produces. It is available with either a 4.5 or a 6.5 h.p., four-cycle, air-cooled, gasoline motor, both units operating with two forward speeds and one reverse speed; however, the larger model has three forward speeds for the rotary tiller. The front-mounted rotary tiller has the unusual feature of operating both in forward and reverse, hence the name Return-Culti. Handles are adjustable 180 degrees in all directions, and the unit's low center of gravity makes it safe for working on slopes. It is most suitable for operations in mulberry fields, orchards, tea plantations, and vegetable gardens, and in addition to cultivation and weeding, can conduct various operations such as fertilizing, cutting stalks, and dislodging roots with a winch mechanism mounted on a frame. The Mametora power tiller Model HMD-25 is a 7 h.p. unit designed for plowing, rotary cultivation, side and middle furrowing, and paddy operations. Some of the more unusual attachments include a two-wheel carrier set for carrying compost and fertilizer, a special blade and cover for making trenches and a mulch dispenser for rolls of plastic. Weight: 97 kilograms without engine.

Above units manufactured by:
Mametora Agricultural Machinery Co., Ltd.
9-37 Nishi, 2-chome
Okegawa, Saitama, Japan

ISEKI Power Tillers

The Iseki Model KS500 is more than a tiller. Its four-cycle, air-cooled, 5 h.p. gasoline engine has six forward and two reverse speeds transmitting power through a gear-/chain-drive system. A few of its many attachments include puddling rotor and puddling rake, turn-wrest plow, ridger, power take-off pulley, auger-digger, as well as a rotary tiller. Another model, with the option of a two- or four-cycle, air-cooled gasoline engine weighs 180 pounds and operates a number of attachments also, including snow-handling and cultivating equipment. It has four forward and two reverse speeds; the main engine shaft is V-belt driven and the traveling section is driven by a gear-chain combination. The power take-off has two speeds.

Iseki Agricultural Machinery Mfg. Co., Ltd.
1-3 Nihonbashi, 2-chome, Chuo-ku
Tokyo, 103, Japan

Land Master Lion

The Lion is available with either a 7 h.p., four-stroke engine or a 6 h.p., two-stroke engine. Two forward and one reverse speed. Attachments include moldboard reversible or non-reversible plow, ridger, rotary cultivator, hoe, puddler, seeder, potato lifter, water pump (27,000 liters per hour, 7.6 meter head), and a thresher for rice and barley with a capacity of 140 kph.

Land Master, Ltd.
Sterte Rd.
Poole, Dorset BH15 2AF, U.K.

WB Power Tiller Model WB1-A

Powered by a four-cycle, single-cylinder, 8 h.p., air-cooled gasoline engine, Model WB1-A is made of heavy steel pipe framing and steel parts adaptable to local (Philippine) conditions with economical maintenance costs. Another unit is available fitted with a 10 h.p. engine. Accessories include moldboard plow, spiral plow, adjustable peg-toothed harrow, paddling steel cage wheel for wet plowing, paddling steel wheel for dry plowing with or without hub adaptor, wheel weight, pneumatic rubber tires, and rotary hoe with 12 blades. The company does export.

Warner Barnes Engineering
A Division of Warner, Barnes and Co., Inc.
2900 Faraday Street cor, South Expressway
Makati, Rizal, Philippines

Staub PPX

Staub offers a wide product line of different-sized tillers and walking tractors. The PPX is one of their most versatile walking tractors. It is powered by a 322-cubic centimeters, four-cycle, 7 h.p. diesel engine. The gearbox houses three forward and two reverse speeds which are controlled by means of a single lever which changes gears and locks the wheels in drive position. Two connections for power take-off are mounted in the rear. Handle assembly is adjustable to all positions and reversible for use with the cutter bar and certain other tools. Attachments include rotary cultivator, plow, toothed cultivator, harrow, trailer, cutter bar, rotary mower, advanced hoe, sower, scraper blade, brush clearer, pump, and saw.

Societe des Tracteurs et Motoculteurs Staub
25, Bd de Verdun
92402 Courbevoie Cedex, France

Honda Two-Wheeled Tractors

A range of models from 2 to 8 h.p. is available with attachments including plows, ridgers, rotary cultivators, and various types of puddling equipment.

Honda Motor Co., Ltd.
Tokyo, Japan

U 1200 Two-Wheeled Tractor

This tractor can be fitted with gas or diesel engines of 8 to 10 h.p. It has a gearbox with three forward and three reverse speeds, and a choice of six PTO speeds. Attachments include mower, rotary cultivator, plow, ridger, harrow, hoe, potato lifter, trailer, sprayer, and belt drive for stationary machines.

Iruswerke Dusslingen
7401 Dusslingen
Postfach 128, West Germany

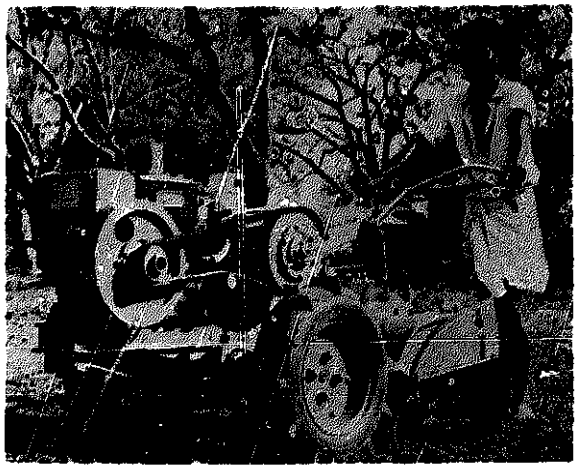
Two-Wheeled Tractors

Six h.p. gas-engined and 12 h.p. diesel-engined tractors are manufactured, together with a range of attachments including plows, rotary cultivators, tined cultivators, mowers, trailers, and others.

Gebruder Holder Maschinenabri[illegible]
7418 Metzingen/Wurtt
Postfach 66, West Germany

Krishi NV 700 Power Tiller

This machine has a 7 h.p. diesel engine and a four forward, two reverse speed gearbox.



Krishni NV700 Power Tiller Krishni Engines, Ltd.

Attachments include fixed and reversible moldboard plows, cultivators, disc harrows, puddling equipment, and others.

Krishi Engines, Ltd.
Sanatnagar, Hyderabad 18
A.P. India

FB 5 Motor Cultivator

The single-cylinder, 15 h.p. diesel engine has four forward and two reverse speeds. Attachments include rotary cultivator, plow, centrifugal pump, high-pressure spraying pump, and trailer.

Fratelli Baraldi s.n.c.
41010 Modena
Via Villanova, Italy

P.G.S. Diamante Tractor

Four-stroke gas or diesel engines of 7 to 10 h.p. are available with two forward and one reverse speed gearbox. Attachments include rotary cultivators, plows, ridgers, trailers, irrigation pumps, spray pumps, and pulleys. Larger two-wheeled tractors are also available.

P.G.S. S.p.A.
Cadeo, Piacenza
Italy

F.B. Motor Hoes

A range of one- and two-wheeled tractors from 5 to 14 h.p. with plowing, rotary cultivating, grading, mowing, pumping, spraying, and transport attachments are available.

Macchine Agricole F.B.
36040 Sossano
Vicenza, Italy

Bertolini Two-Wheeled Tractors

Diesel engines range from 8 to 21 h.p. Attachments include plows, rotary cultivators, trailers, irrigation pumps, and sprayer pumps.

Bertolini Macchine Agricole
42100 Reggio Emilia
Via Guicciardi 7, Italy

Goldoni Two-Wheeled Tractors

Gas- and diesel-engined models from 7 to 21 h.p. are available with plowing, cultivating, spraying, pumping, and transport attachments.

Goldoni S.p.A.
41012 Migliarina Di Caripi
Modena, Italy

CB 450 Tractor

Plowing, rotary cultivating, tined cultivating, and mowing attachments can be supplied for this tractor.

Mabec
27 Rue D'Orleans
92200 Neuilly-Sur-Seine, France

Allen Mayfield Tractor

The Allen tractor can be used with a mowing attachment, with a tool bar carrying cultivating tines, hoe blades, or ridging bodies, with a single furrow moldboard plow, or for pulling a trailer. Seven or 8 h.p. engines and three speed or three speed and reverse gearboxes are available.

Allen Power Equipment, Ltd.
The Broadway, Didcot
Berkshire 0X11 8Es, U.K.

Super U 70 Tractor

The Super U 70 tractor is fitted with an 8 h.p. engine and a four forward, two reverse speed gearbox. Individual wheel clutches facilitate steering. Attachments available include a mower, plow, rotary cultivator, and trailer.

Gutbrod-Werke GmbH
6601 Bubingen, Saar
Postfach 60, West Germany

"DEAR DETROIT, THANKS, BUT NO THANKS"

by Gene Logsdon

If American business is really interested in satisfying *my* needs, I haven't seen a whole lot of proof. I never needed or wanted these gas-hogging, chrome-laden, corner-lurching monsters Detroit built for me for so many years. For their error, our car makers had to watch Volkswagen take all that money away from them with an ugly little car Detroit thought Americans were too dumb to buy.

The tractor makers haven't learned their lesson yet, it seems. I don't doubt that those new 20 to 30 horsepower tractors that appear to be tailored to the homestead are worth $6,000, or at least have $6,000 worth of parts and labor in them. But many of the refinements on those tractors aren't necessary or affordable for the homesteader whose aim is not to generate cash profit from his food production. The tractor I need does not have to be a powerhouse that can do everything except brush my teeth. For instance, it doesn't need rubber tires. Iron wheels would be just fine and would never go flat. I'm not going anywhere with this tractor except back and forth across my little 20 acres, slowly. I don't need a dozen forward speeds. Two will be adequate—and one reverse. My tractor needs no expensive shock system. Any bumps on my place I intend to engage at one or the other of my two forward speeds—slow and slower. I do not need a bucket seat, cigarette lighter, twin-beam headlights, dashlight, radio, cab, high-capacity hydraulics, double-plate clutching, syncromesh gears, hydrostatic transmission, or power steering. All I want is something that will pull as much as three horses and just as quietly.

Can't American technology come up with a long-lasting, easy-running, air-cooled engine so we can dispense with radiators once and for all? A motor that chugs easily along like the old two-cylinder John Deeres would be wonderful. And speaking of old John Deeres, why can't my ideal tractor have an easily turned flywheel crank so I can dispense with high-priced batteries that always seem to be dead when you need them most?

Lastly, is it too much to ask for a tractor which even a mechanical simpleton like myself can take apart easily? I don't mind buying new parts for a piece of machinery if only I could replace them myself. It seems to me that a simple tractor that takes the place of three horses should come apart with any good set of wrenches so that you can get to any broken piece in less than an hour.

The real reason I haven't seen the tractor of my dreams might be that it wouldn't make enough profit for the manufacturers and dealers. Several years ago, I was involved in an article about how farm equipment companies were coming to the aid of underdeveloped (how I despise that word) countries. I don't know if anything came of their praiseworthy plans, but in the course of talking to one executive, he described to me what his company had in mind. They intended, he said, to build a low-cost tractor with a four to six horsepower engine that would still pull the tools similar to, but improved over, those which draft animals traditionally pulled (which our 15 horsepower lawn tractors won't pull). The tractor would be so simple and durable it would rarely need repair work, but when it did, even a mechanical ignoramus could fix it most of the time.

I gasped, genuinely impressed. "That's the kind of tractor *I'm* looking for," I exclaimed. "Why don't you sell it in the United States?" He laughed. No, Americans wouldn't buy that kind of tractor. Market analyses showed Americans buy for status and would reject a truly economical tractor, he said. Then, seeing disbelief written all over my face, he weakened in a moment of candor. "Actually," he said with a grin, "we're afraid to market that kind of tractor here. It might capture too much of the market where our more profitable models are doing nicely now."

Another aspect of the company's plans for a simple tractor was even more significant. The plans called for a very small tractor not only because of cost and simplicity of operation, but also so that it would not give one small farmer any competitive advantage over another. The idea was just to *replace* the farmers' present power unit—draft animals—not to make it possible to farm more land. The tractor was intended not as a machine for aggrandizement which would eventually put the land in the hands of fewer people and destroy the present social structure, but which would only relieve some

of the toil of primitive farming, redirect more food from draft animals to humans, and improve production because the tractor implements work the soil better.

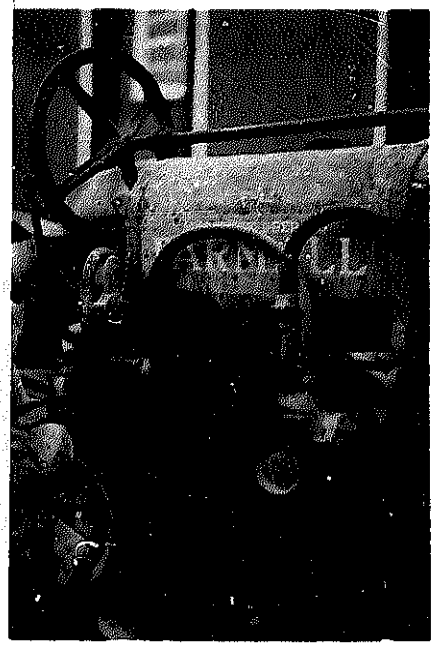
I don't know whether replacing hand and animal power with machine power is right for underdeveloped countries in the long run, but the thinking of the equipment company is revealing indeed, and certainly a step in the right direction. Someone evidently realized that what we have done in the United States might not be the best way to develop a country. The tractor never replaced the horse in this country; it replaced the farmer. The more powerful the tractor, the more farmers it replaced. At no time were the promises of the Machine God fulfilled except temporarily to the survivors in the get-big-or-get-out race. Each improvement in machinery meant more farmers out of business, so that today less than 5 percent of the United States' population produces the food and owns the land. What a shame.

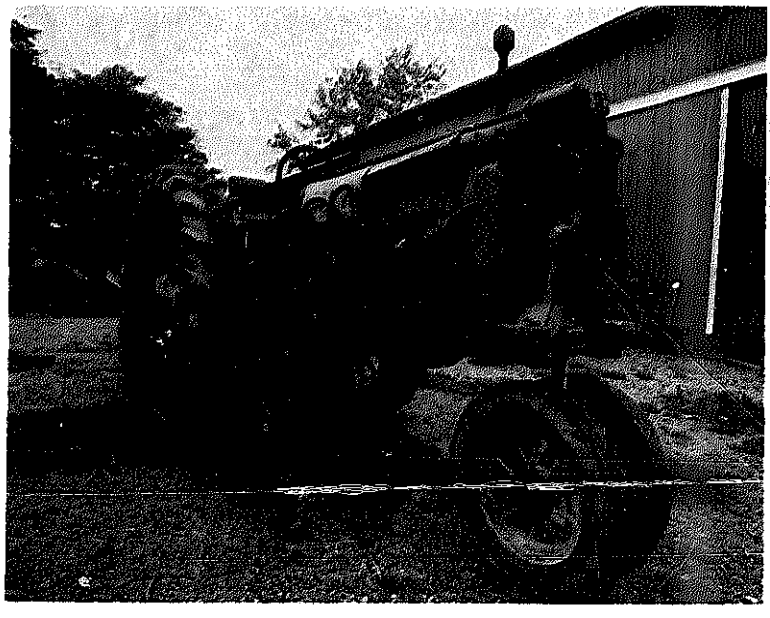
The only practical solution I found was to look for an old run-down tractor and repair it. You know the old saying, "They laughed when I sat down at the piano." Well, my friends absolutely roared when I sat down under an old junk tractor and said I was going to make it run again. I can't blame them. As my wife would put it, I have just enough native mechanical ability to unlock a door—if someone turns the key for me.

But to tend my 20 acres, I had to have a small, farm tractor. Something that would pull a seven-foot sickle mower, or an eight-foot disc, or a two-bottom plow. Twenty-five horsepower would do just fine. And naturally I wanted a tractor that wouldn't cost much.

That meant finding a junk tractor and burying myself in grease and gasket glue for a month or two of weekends, a prospect I did not find inviting. But wasn't I the one who was always pointing out that the homesteader who could not be his own handyman and mechanic was headed for failure? It was time to practice what I preached.

Hydraulic improvisation





With a bit of ingenuity, tractors can be modernized like this old Farmall F-12. The owner installed a hydraulic lift system, covered the steel wheels, and now prefers this tractor over his many others for all his farming chores.

The used tractor market is a never-never land of intrigue and mystery, I soon discovered. In no sector of our economy does free-enterprise capitalism flourish so vigorously. Demand is the whole game. A tractor that ten minutes ago was worthless (which means priced under $300) suddenly rises in value to $950 because a couple of what the tractor salesmen refer to as hobby farmers showed interest in it.

In the horsepower range I was looking for, old Fords, Fergusons, Ford-Fergusons, and John Deeres with three-point hitches are in biggest demand right now. Such tractors in good running order will sell for over $1,000 (1975 price). Comparable tractors without three-point hitches go for around $700. If in poor shape, both kinds of tractors could be as much as $400 lower. So, for one of the less desirable models in poor shape, you might pay around $300 and put it in running order for as little as $200 more, not counting your labor. But even if you had to shell out another $200 for repairs, you'd still have a good bargain.

I didn't really need the convenience of three-point hitch equipment, so I decided on one of the less desirable old tractors. I selected a WD Allis-Chalmers made about 1950. For one thing, I could get it cheap, and second, the owner was an especially nice fellow who let me use his tools and helped me with the overhauling. Third, the WD is a fairly simple tractor to take apart and put together. Fourth, it has a reputation of running even for hammer-head mechanics like me. Fifth, the WD has a power lift system almost as convenient as the three-point hitch. And finally, the tractor has both a hand and a foot clutch, which gives you the equivalent convenience of live power take-off found on modern tractors.

My son and I have the tractor running well enough to work our wheat field and mow the fall pastures, and it only cost me $500. There's more work to be done, but I have all next winter for that and I figure I'm still ahead with my old junk. Before long it will be as good as new.



Old steel wheels are kept from the junkyard by bolting rubber treads over them.

But I'm not the only one who prefers the older models. "I farmed my 132 acres in my spare time for about 25 years with tractors in the 20 to 30 horsepower range," says Harrell Noble from Xenia, Ohio. "Mine were old tractors when I bought them, and I still use them. I don't think it makes much sense for a part-time farmer to invest $5,000 to $7,000 in a new tractor. On my kind of farm, plowing 1½ acres per hour with my older tractors seems more sensible than plowing four to six acres per hour at five to ten times the investment."



This old Farmall is like just another member of the family.

Noble's first tractor back in 1952 was an Allis-Chalmers WC, which with an old disc, plow, manure spreader, and row planter (the tools you almost must have at the start) cost him around $700. Next he bought an F-20 International (1939 model) so that both he and his son could work in the field at the same time. His third tractor, a rebuilt 1942 Farmall H, he still refers to as his modern tractor. He's had two more over the year—another F-20 made in 1935 and a Farmall M which would pull a three-bottom plow.

"One advantage of buying older tractors is that you can afford more of them," says Noble. "Having several tractors can be very handy. At haying time, for instance, you don't have to keep hitching and unhitching tractors. We could leave the mounted cultivators on the H, rather than having to take them on and off for other pulling jobs. We'd use the Allis-Chalmers to pull the mower, one F-20 to rake, and the other F-20 pulling the baler. With the hay all mowed, the Allis-Chalmers was free to pull the wagons back and forth from the barn to the baler in the field."

But having an extra tractor can repay its cost in more than just convenience. "One year, one of the tractors broke down when we had a lot of hay ready to bale. The repairman couldn't get it fixed until the following week," recalls Noble. "I quickly hooked another tractor to the baler, with still a third one free to haul the loads of bales to the barn. Just as we finished, a rainstorm struck and the weather remained wet for a week. Having that extra tractor saved 50 tons of hay, in those days worth $1,000. We literally paid for two of those tractors in one day."

Jerry and Jean Harper in Indiana also have two tractors, which they refer to as "His" and "Hers." "His" is a Farmall H, 1952 vintage; "Hers," a Massey-Harris of about the same age. The Farmall needed a complete overhaul when they bought it. Harper tore it down, took the head to a

machine shop for valve grinding. He put in new pistons, rings, sleeves, rod bearings, and crankshaft bearings at a cost of about $100 plus labor.

When I was overhauling my WD Allis-Chalmers, after I got my tractor torn down, I found just about everything was worn out, so while new parts are still available from the company, I went whole hog and had a mechanic rebuild almost everything. Now I have a fairly new 25-year-old tractor at a fourth of the cost of a similar-sized new tractor. An additional benefit you sometimes gain from keeping up a vintage tractor is that it begins to accrue antique value after awhile. Restoring old tractors has become almost as hot a hobby as restoring old cars.

Another thing—get the service manual for your tractor if at all possible. On most makes, they are still available if the company is still in business. Extra-proper care is necessary for old tractors, and you just can't know everything you should do without the manual.

"By all means, get the service manual," seconds Bill Bennett in Wisconsin, who owns an older Ford 8N, the most popular homestead tractor of all. Manuals for most major models of tractors (Allis-Chalmers, David Brown, Case, Deere, Ford, International Harvester, Massey-Ferguson, Minneapolis-Moline and Oliver), both new and old, are available from I & T Shop Service, Technical Publications, P.O. Box 12901, Overland Park, KS 66212. Bennett began homesteading in 1972 on 40 acres. "About 37 acres were under rental contract to another operator the first year, so we could handle three acres with our big tiller," he says. "But when the 37 acres came out from under the rental, we knew we had reached beyond the tiller stage.

"Some folks opt for the big suburban garden tractors, mistakenly, I think. They are fine for a couple of acres, but not for a small farm—and they cost as much per pound as a Cadillac."

First, Bennett checked out the moderate-sized new tractors on dealer lots. "They are exciting machines with many improvements over older tractors, but cost at least $5,000—hard to justify on a not-so-commercial farm." So he started out on a quest for the simplest, cheapest, used rig in the real tractor category.

"We narrowed our search to the Ford models 8N, 9N, and 2N (depending on year of manufacture, 1939 to 1952); Massey-Ferguson models 20 and 30; the John Deere B; the Allis-Chalmers WD; the Farmall A, C, and H models; and the Case C and D. Fords seemed less rare than the others, so we tried to find one. Finally opportunity knocked. A machine repair shop in the township offered a shining 8N, overhauled, restored, repainted and guaranteed for $1,600. With it was a useful, hydraulically operated front-loader, said to be worth another $400. The tractor also had a two-range transmission, which means you can gear down and creep in difficult pulling situations. That provided eight forward speeds, as contrasted with the usual four on a model 8N—an accessory said to cost $200. So we figured the tractor was a good buy and have never regretted our purchase."

The earlier model, 9N (1939 to 1947) offers three forward speeds, while the 8N (1948 to 1952) has four. "You can't pull much of anything in fourth gear," explains Bennett, "but it allows you to speed up to twelve miles per hour over the road, handy for tooling over to the local garage for a tune-up."

Both these popular old Fords are rated at 23 horsepower. They are heavy and rugged and will handle a one- or two-bottom mounted plow, or an eight-foot disc, mounted or trailing.

New parts for old tractors are obtainable through the dealers who sell that make of tractor. New parts, even for older tractors, are not cheap. You can sometimes save appreciably by shopping the huge used tractor and junk tractor centers located all over the Midwest. Ask farmers or mechanics in your area for the supply centers closest to you. Some of them are: Worthington, MN 56187; Wenger's Farm Machinery, Inc., South Race St., Myerstown, PA 17067; Al Galloway, St. Johns, MI 48879; Willard Equipment Inc., St. Rt. 99N, Willard, OH 44890; and Central Tractor 1515 East Euclid, Des Moines, IA 50313. I've gotten parts at Willard. There are thousands of junked tractors there. It's a tractor restorer's paradise—or maybe nightmare. Dealers seem to have a pretty good idea of what they have in all that mess, so it pays to call ahead. But it pays to go looking in person, too.

"One place that sells the gamut of vintage tractor parts on a mail-order basis is the Tractor Supply Co., 7910 L Street, Omaha, NB 68127," says Bennett. "The company issues a big catalog annually and also has stores in farm towns in 27 Midwest states." Surplus Tractor Parts Corporation, P.O. Box 2125, Fargo, ND 58102, ships worldwide, and has a catalog available for $1.

An English-based company, the Vapormatic Company Ltd., P.O. Box 1, Budleigh Salterton, Devon, EX9 6JB, England, also specializes in tractor replacement parts for all major models. It has associate companies in several countries around the world, including Australia, Ireland, France, Holland, South Africa, Northern Ireland, and the United States.

Finally, where do you find the tractors? This is one time when the classified ads can be most helpful, especially in rural newspapers. Or even more especially, rural trading papers that are nothing but classified ads.

The second best place is at farm sales. Look at the sale announcements in your papers. Farm sales are usually on Saturday, and the notices always list the machinery to be sold several days to a week early. The third best place is at dealer lots. Even when dealers don't have the old equipment you need, they sometimes know where some is available.

I'm forever griping that the farm machinery manufacturers don't make tools to fit the two- to 20-acre homestead. But every time I wonder out loud "why don't they make such and such," sure enough I soon find out someone *is* making such and such.

Those of us familiar with the old Allis-Chalmers model G tractor remember its passing with tears in our eyes and terrible envy for those still lucky enough to have preserved one. The G is the ugliest tractor ever built; it looks like an arthritic spider trying to do push-ups. But there is no handier cultivating machine ever made for the large truck garden. It will turn sharp enough to turn itself inside out, and can be maneuvered (from the seat hovering over the plants) so easily that you could tickle the potatoes in their hills without harming them. No machine is designed to take attachments easier or can be repaired with less trouble. The G doesn't wear out—and the only way to get one is to inherit it.



The original Allis-Chalmers G: "The only way to get one is to inherit it."

But G lovers don't have to eat their hearts out any longer. There's a new small tractor on the market that looks and acts a lot like the old G. It's called Tuff-bilt, made by Tri-Tractor Manufacturing Co. (Rt. 1, Hwy. 19 North, Cumming, GA 30130). When I first heard about the tractor, the rumor going around said that the company was so small you could order your tractor in any color you wanted. "Well, that's not quite true," says Jerry Gravitt at Tri-Tractor headquarters in

Cumming. "That story got started because all the other machinery companies who wanted to sell the Tuff-bilt wanted it painted in their own colors. So we painted 'em orange, blue, or green depending on whom the order was for."

The tractor runs on a 16 horsepower, air-cooled, Lawson Tecumseh engine with all-gear drive and individual left- and right-hand brakes. It uses only about a gallon of gas an hour and has plenty of high clearance so you can cultivate over corn and other crops with ease. Cole and Brinly-Hardy tools fit the tractor, and there are all kinds of other attachments too—mower, 12-inch plow, 26-inch disc plow, cultivators—the works. The price is just under $2,800, which isn't bad considering that this is about all the tractor you really should need for handling 20 acres or so. "With a complete set of tools, you're talking about $4,200," says Gravitt, "which is quite a bit less than just the basic price on a regular small tractor."

Another company to bring back a version of the Chalmers G is John Blue with their Model G-1000. It's a bit larger and heavier than Tuff-bilt but the design is right there. With the engine mounted on the back, there is better traction and the front is left with clear visibility. Implements attached to the front let the operator watch with greater ease and drive with greater accuracy.

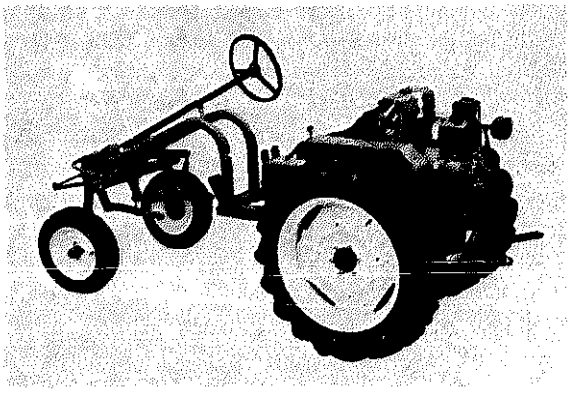
The Blue G-1000 had a slow start when it came out four years ago. "It was a novelty and folks were skeptical," reports Cecil Walker of their Bowling Green, Ohio, plant. But now it is really catching on with weekend farmers and garden folks—the garden implements are going with it. Surprisingly enough, sales have really taken off in Chicago.

Hefty has two models of the old-style G, a 27 horsepower, rear-mounted unit and the Hefty Hi-G. The Hi-G was particularly designed for nursery and agricultural applications where 36 inches of clearance and unrestricted visibility are required.

NORTH AMERICAN SOURCES OF MODEL G TRACTORS

Tuff-bilt

The smallest of the new G models available, the Tuff-bilt has a 16 h.p. engine for powering the liquid-cooled, hydrostatic transmission and two category O three-point hitches with 400-pound lifting capacities, front and rear. Implements available for use on the Tuff-bilt include front and rear cultivators, front attachment for the Cole No. 12 planter (page 204), disc harrow, three-point drawbar, 12-inch-bottom moldboard plow, 54-inch grader blade, a 26-inch disc plow and rotary mower.



The Tuff-bilt tractor—a lot like the Allis-Chalmers G. Tri-Tractor Mfg. Co.

Tri-Tractor Mfg. Co.
Rt. 1, Hwy. 19 North
Cumming, GA 30130

Blue G-1000

The Blue G-1000 has a 16.8 h.p., water-cooled, four-cylinder gasoline engine. It has a Warner gear transmission with three forward speeds, and high and low reverse speeds. Hydraulic lift is standard but the live PTO is optional. The G-1000 can be operated with a single-row cultivator, 12-inch moldboard plow, 60-inch three-spindle mower, 6-foot single-section disc harrow, or a 5-foot spring-tooth or spike-tooth harrow.

John Blue Co.
P.O. Box 1607
Huntsville, AL 35807

Hefty Hi-G

A high ground clearance of 36 inches provides the Hi-G with its outstanding feature and its name. As is characteristic of all type G trac-



The Hefty Hi-G



The Hefty-G
Diana Branch

tors, its 27 h.p., water-cooled, gasoline or diesel engine is mounted in the rear, and the driver enjoys unrestricted visibility. A front-mounted, three-point hydraulic implement lift system or rear-mounted hydraulic furrowing bars support the ground-working tools. Its high ground clearance design is particularly suited for nursery and agricultural applications, but the high center of gravity makes it unsuitable for working on steep slopes. The selective sliding gear transmission has six forward and one reverse speed, providing a maximum forward speed of 13 kph. The 2- by 4-inch, welded rectangular steel tube frame is 82 inches high to the top of the steering wheel, has a 76-inch wheelbase, and weighs 2,440 pounds. A 12-volt electrical system operates a starter, generator, and four sealed-beam headlights. Available as optional equipment are a 540 rpm power take-off, live engine speed, front center power take-off, two-cycle, water-cooled diesel engine, variable tread widths as low as 4½ inches or up to 120 inches, single-row or multiple gang independent cultivator assemblies, rear hydraulic furrow and bar assembly, and rear drawbar kit.

Hefty Gw

Incorporating the same engine, transmission, and frame construction as the Hefty Hi-G, the Hefty Gw has a lower center of gravity with its

lower, 19-inch ground clearance. The wide wheelbase straddles up to four rows or more of vegetables, reducing planting, cultivating and thinning time. It also has two specialized power take-off shaft outlets: one live at engine speed, one synchronized with ground speed. Optional implements include a 60-inch mid-mount rotary mower, single- and two-row cultivators, Danish fiber tine, spring-trip and spring-tine, double toolbar cultivator, midmount blade, and hydraulically controlled rear-mount furrowing bar with shanks. If you want the lower center of gravity of a Hefty but don't need the wider wheel base, a model called the Hefty G is available with a narrower wheelbase.

Hefty Tractor Co.
P.O. Box 188
Juneau, WI 53039

YE OLDE CHALMERS B AS HOMESTEAD TRACTOR

by John F. Sutton

If you're looking for a economical homestead tractor, you might consider one of the earliest of the utility-type tractors, the Allis-Chalmers Model B. This machine could be the workhorse tractor of today's homestead.

Rated at 20 horsepower, the B is considered a single-plow tractor, but depending upon soil types and conditions, it is capable of pulling a double plow.

While the B is a farm tractor in size, its power, workability, and durability make it superior to any of today's largest garden tractors, and its price, $150 and up, is a far cry from any other farm tractor or new 20-horse garden tractor.

A wide variety of attachments were produced for this versatile little tractor—mowers, cultivators, single-bottom mounted plows, and a rather unique two-way plow designed to allow plowing while traveling back and forth on the same furrow.

Don't limit yourself to mounted accessories. The B can easily pull a variety of manure spreaders, trailers, discs, drags, and planters. The power take-off will handle balers, blowers, rakes, and, best of all, the belt pulley will power feed grinders, saws, and small threshing machines, which are so handy in homestead and small farming operations.

Some of these tractors are equipped with a small hydraulic system capable of handling mounted plows, cultivators, and other assorted lightweight implements. For the most part, snow blades and manure buckets are homemade and thus of a wide variety.



Sutton on his old Chalmers B.

The B was introduced in 1937 as a lightweight general-purpose tractor; it is precisely this age factor which makes the B a very attractive tractor for the homesteader. Because of its age, the B often sells for less than $300 at farm auctions and between $300 and $500 through tractor dealers.

Even here in Wisconsin, where these tractors are highly prized by tobacco farmers, the prices remain low. Also, because of their age, they are simple machines and are economical to operate.

I prefer the hand start model, because of the simplicity of the mechanical workings of the tractor. The only concern with a hand start is the potential kickback of the cranking handle. Any indication of a backfire or kickback is a sign that it is time for maintenance.

At any rate, if you hold the crank properly (that is, with your thumb on the same side of the handle as your fingers), at most the flying handle may kick back and sting your hand, but there will be no broken bones.

Can you really homestead with the old Chalmers B? Absolutely! I have heard of people farming up to 80 acres with one B and a few attachments. My father-in-law farmed 280 acres, including up to 21 acres of tobacco, with a couple of Bs, an old Chalmers WC, and a good team—and with one of the Bs running the milking machines for 40 to 45 Jersey cows.

My wife, son, and I recently raised two organic acres of tobacco with our oldest B (hand start) doing all of the disking (no plowing) and all other soil preparations, planting, cultivating, and harvesting. And the old B could have handled more acres had we the time and fortitude.

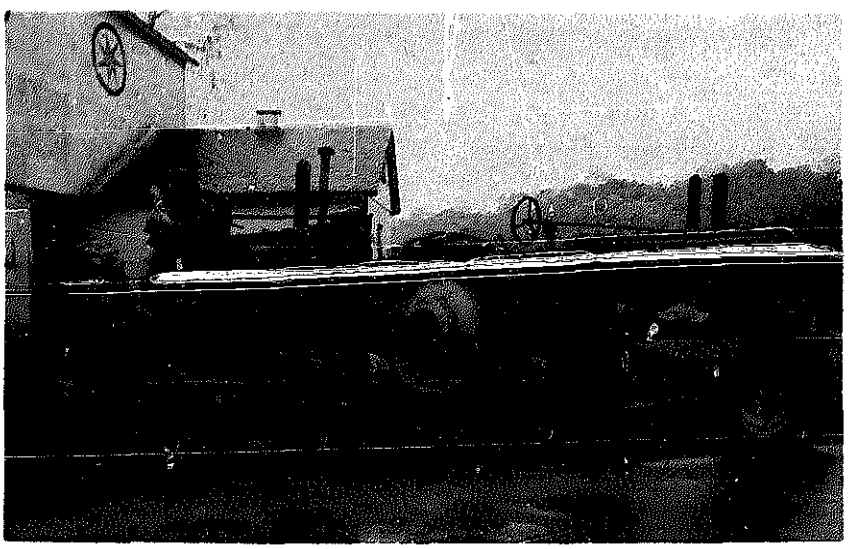
Parts for all models are still readily available and inexpensive if purchased wisely.

THE CARE AND FEEDING OF TWO-CYLINDER JOHN DEERE TRACTORS

by Arnold Voehringer

The big, green, two-cylinder John Deeres of the pre-World War II years stand almost in a class by themselves as models of appropriate technology. They were built with one goal in mind—to perform the jobs for which they were intended as simply and economically as possible.

The two-cylinder John Deere is a fine example of form strictly following function. With its low compression ratio, it seems to run on just about anything. That little tank behind the main tank is for gasoline to start the tractor and warm it up. Then you switch to the main tank, which can contain kerosene, heating oil, or diesel fuel, as well as regular gas.



"No better tractor," says Arnold Voehringer of his vintage John Deeres. The 1936 and 1939 (styled) Bs seen here are adapted to a wide range of jobs on farms of all sizes.

The rugged elegance and almost primitive simplicity of design that are the trademarks of those machines that came out of John Deere's Moline, Illinois, shops are typified by features such as their flywheel starting system. While other manufacturers introduced fancy self-starters with batteries that went dead, and crank starters with their penchant for kicking back and breaking thumbs, John Deere opted for the big exposed flywheel, which almost always turned over on the first or second turn. The operator simply opens the petcock for each cylinder and pulls the flywheel (my wife can start our B with one hand) to top dead center, at which point the magneto fires and the tractor snorts to life.

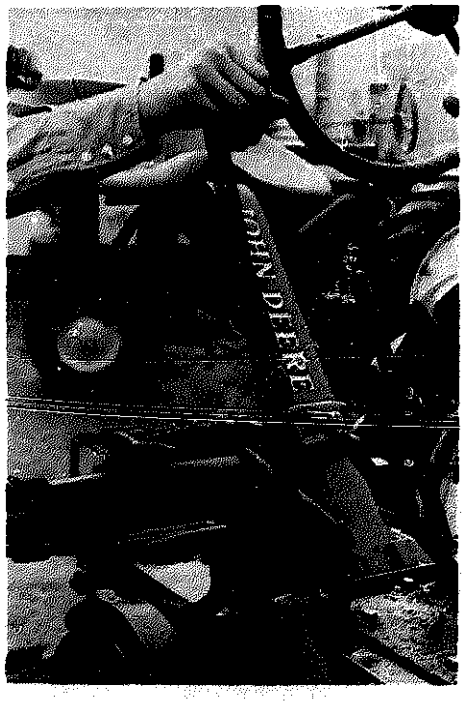
The thermo-syphon cooling system bypasses the need for a water pump by capitalizing on that elementary law of physics that says hot water rises and displaces cold water in a closed system.

Another advantage of the old Deeres is the safety aspect of the hand clutch. When a foot slips off the pedal of a conventional clutch and the tractor lurches forward, the result is potentially catastrophic. Should the A or B with hand clutch jerk forward, it effectively pulls the clutch rearward and the tractor stops.

With their low center of gravity created by the horizontal engine, J.D.s are less prone to rolling over on hilly terrain. Also, with the engine closer to the rear axle, traction is improved. While this means the front end is correspondingly lighter, it can be correctd simply by the use of front-end weights.

But even beyond the hand clutch, the flywheel starter, and the interchangeability of parts, the old Deeres had something else going for them. They sounded right. It's a sound no one who is familiar with the unmistakable, sunup to sundown putt-putt of a two-cylinder J.D. going about its business on some hillside halfway across the county, or who has experienced the magnificent, unmuffled din of that engine set at full throttle for filling silo, is ever likely to forget.

With just two cylinders, there are fewer parts to replace and repairs are easy, even for the operator with very limited mechanical aptitude. With a peak rpm of 975, the John Deere A is a relatively low-revving engine, and is much less sensitive to exact tolerances than modern tractors. Just about everything that can go wrong can be fixed by anyone with a maintenance manual and some basic tools. Adjusting the clutch, for instance, almost invariably means an expensive trip to the



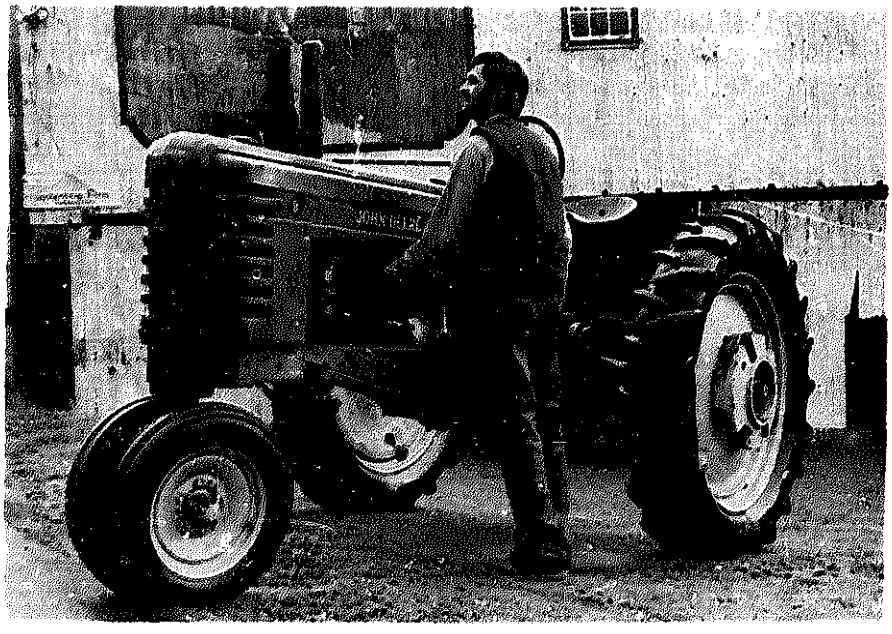
The hand clutch is a real safety plus, especially with young operators.

dealer with any modern tractor. All that's required to do the same job on an A or B are pliers and a ¾-inch wrench. Likewise for the carburetor adjustment. You just turn in the screw till you hear the pop, then turn it out until the black smoke appears. With the bearings, both the main and the connecting rod bearings are simple to adjust—a far cry from some of today's sealed roller bearings. The same simplicity applies to work on the steering, ignition, brakes, and any number of jobs that are major headaches with more sophisticated technology. Even the transmission, with its big, rugged gears and one-piece housing, is much less intimidating than its bewildering modern counterparts. Since the crankshaft turns parallel to the rear axle, not perpendicular as is the case with most later transmissions, the power is transmitted directly through the spur gears instead of around corners.

Unlike some other tractors of similar vintage, parts are still widely available for elderly J.D.s. The regional farm magazines regularly run ads from parts dealers. Many John Deere dealers still have parts on hand or can order them. The dealer is also the place to order a repair manual and parts book, both of which are worth their weight in gold if you do your own repair work.

This discussion is confined to the A and B models, since many more of them were made and, consequently, are still available. The two models were designed for two specific categories of farmer.

On my own hillside farm near Kempton, Pennsylvania, I use my 1936 B for mowing in the summer and sawing firewood in the winter, my 1939 B for cultivating, a 1947 A for disking, drilling,



"Just turn in the screw until you hear the pop, then back it off until the black smoke appears."

and spreading manure, a 720 diesel for plowing, baling, combining and picking corn, and a 1939 G for hayridges, secondary tillage, pulling wagons, and running a hammermill.

For the small farmer with five or ten acres and no more four-legged animals than, say, a horse and a goat or cow, the B is ideal. Unless it's a late model, big-piston B, or you have exceptionally loose soil, don't count on pulling more than a two-bottom, 12-inch plow. The A is a different story. You can run a 60-inch flail chopper, a baler, a combine, or a four-row front-mounted cultivator with an A. It may not get over the ground quite as fast as some of today's behemoths, but it's just right for most jobs on the small farm.

The big difference between John Deere's letter series (A and B) and their corresponding number series (60 and 50) is that the latter offers live hydraulics and live power take-off, a real asset when it comes to baling, combing, and corn picking. If you have live PTO and your baler starts to jam,

you can pull out the clutch to stop the tractor without stopping the baler. Without the live PTO, the baler stops too, and once you stop a jammed baler, you'll never get it started again without unplugging it by hand. Three-point hitch attachments can be purchased for the A or B, enabling the operator to use the full range of newer implements.

The B started out in 1935 with a drawbar horsepower rating of nine and ended up in 1952 with a rating of 20. The A started out as a 16 horsepower drawbar tractor in 1934 and finished in 1952 with 26. Until the big tractors (40 horsepower and up) started to arrive on the scene around wartime, these tractors were generally regarded as *the* best source of power. Today, by virtue of their size and weight, they are often better-adapted to operations on the small farm than their streamlined modern counterparts.

Fortunately, many two-cylinder John Deeres in good condition are still available at sales. In the eastern U.S.A. (in 1977), Bs are bringing from $00 to $700, As about $1,000. The 50s and 60s are a little higher.

When sizing up old J.D.s at a farm sale, how do you tell a good one from a clunker? Here are a few easy checks:

1. Check the side play in the hand clutch. There is no grease fitting at the bushing, so unless a new bushing and pin have been installed (which you can usually tell), this play is a good indication of how hard the tractor has been used. Anything over three-inches play should be viewed with caution.
2. Check the play in the radiator fan. Again, three inches should be about tops, although I've seen four and five inches of play in tractors still being used daily.
3. Check the steering wheel play and the brake pedal side play. The left pedal may be a little looser, especially if the tractor has been used mainly for plowing with a conventional plow.



Flywheel starting beats cranking any day, the author reports.

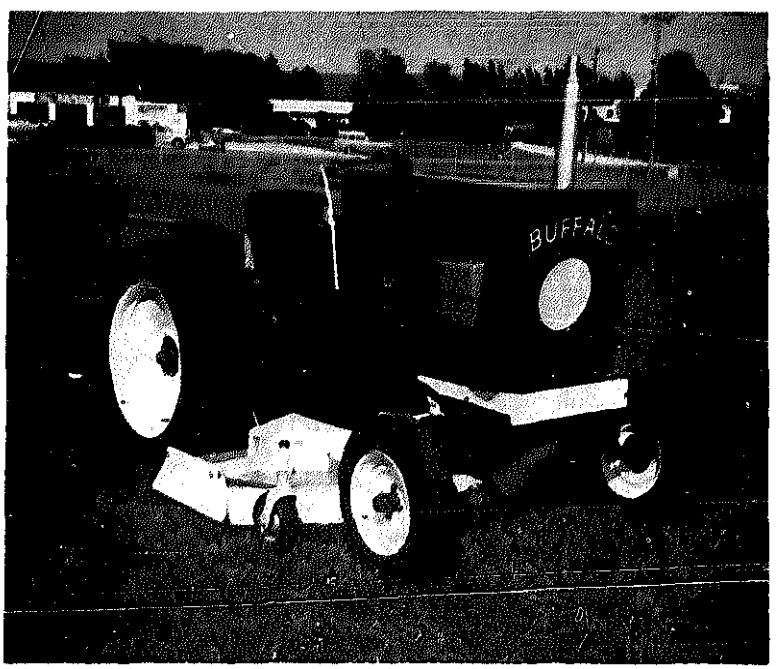
4. Grab the flywheel and try to shake it. If it moves more than the slightest bit (.010 inches), steer clear.
5. Check for large leaks from oil, water, transmission, gear oil, and hydraulics. There should be no signs of oil in the radiator or water in the crank case.
6. Check the block and manifold for cracks. With two cylinder J.D.s, if you can't see the cracks there probably are none.
7. Check the rear-end housing. The best of the three types John Deere used is the Power-Trol, which allows the use of either a single- or double-acting hydraulic cylinder.

With so much to recommend them, what are the chances that John Deere might be prevailed upon to reintroduce a two-cylinder tractor in the 20 to 40 horsepower range? After all, the stock of parts around the country won't hold out forever. Not very likely, say J.D. marketing people, who argue that the largest of their current line of garden tractors and the smallest of the "Long Green Line" of utility farm tractors (the 36 horsepower 830) effectively overlap to serve this market. Maybe so, but speaking as one who has his doubts, I can see a legitimate case to be made for the two-cylinder as the tractor of the future.

THE BUFFALO

The Buffalo is an outgrowth of a little tractor Vern Schield invented in 1963 called the Self-Helper. It was developed to aid emerging nations in their transition from muscle to machine power. Self-Help, Inc., manufacturer of these tractors, is a nonprofit organization that only sells outside the United States.

The Waverly Tractor Company in Iowa modified the Self-Helper design to meet United States safety standards and now produces their model, the Buffalo, for sale here. They use recycled automotive parts to allow the Buffalo to compete in price with imported models. Vern Schield, inventor of the Self-Helper, makes these points about the Buffalo, "We have found that the Chevrolet differential used in 1955 to 1964 cars invariably outlasted its original application. When gears run together for 50,000 miles and still mesh within specifications, you know the differential was well



The Buffalo

designed. General Motors made millions of them and we only pick the best. In our application, it can last for years. Sure it helps America not to waste its waste, but most of all it helps us build a tractor you can afford. We have no reservations about guaranteeing everything we use."

The transmission is from a ¾-ton Ford or Chevy pickup. V-belts acting as a clutch make a two-to-one reduction from the 25 horsepower, air-cooled engine to the transmission. Except for a few later models, all American-manufactured combines and forage harvesters have such a V-belt drive from the engine.

Waverly Tractor Company's original intentions were to purchase a steering section from one of the manufacturers that make this type of equipment for small tractors. However, they found a Saginaw steering section which was standard on most General Motors cars, as well as Ford and Chrysler. It was easier to install and much heavier than the steering sections manufactured for this purpose. So, naturally, this was their choice.

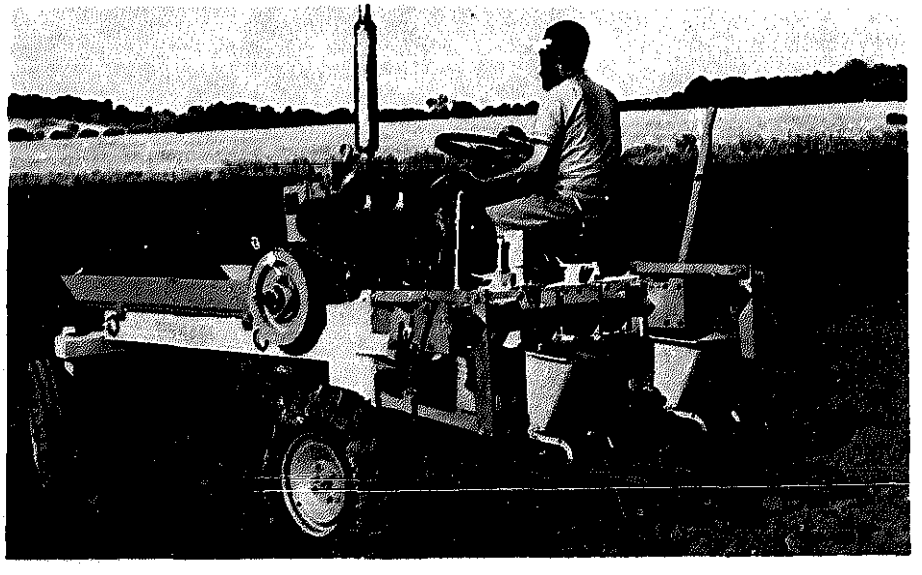
Waverly Tractor doesn't fit any mold. The factory is in an old buffalo pasture, next to the shed where the first prototype now lives. The field testing is done by teenagers—nobody can break things faster than two kids competing. Everyone who works for the company wants to be there. Some employees have quit better-paying jobs to do so. Others have started cottage industries, working in their homes and usually furnishing their own equipment. Several partially handicapped people are turning out quality parts for the Buffalo. Schield feels that this, too, is a resource that should not be wasted.

Turning discarded materials into marketable products is not only a rewarding experience, but it is also good business. Seeking this combination has led Waverly Tractor into many interesting developments.

Waverly Tractor Co.
Sleeping Giant–Hwy. 3 East
Waverly, IA 50677

AFRICA'S OWN, THE TINKABI

Africa is proud to announce the arrival of its own tractor, the Tinkabi. With a name derived from the Siswati word for oxen, the Tinkabi was designed under the aegis of the Swaziland government and the National Industrial Development Corporation (NIDC) of Swaziland to give small

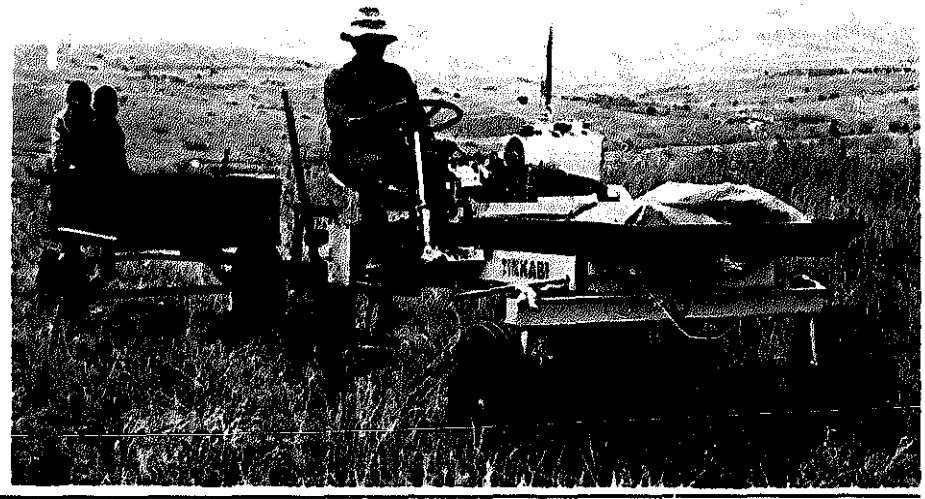


The Tinkabi with seeding attachment
National Industrial Development Corp.

farmers the opportunity to mechanize. As the NIDC theory goes, ". . . if [the] agricultural Third World is to develop, it is essential that a simple, low-cost tractor is made available to the farmer to increase his productivity and income."

The Tinkabi has many features not normally found on other tractors. Its front loading platform is capable of carrying 500 kilograms. The addition of a trailer brings the transport capacity to 2,000 kilograms. The heart of the tractor is an air-cooled, hand-started, twin cylinder, 16 horsepower engine which, under normal farm use, consumes less than 1½ liters of diesel fuel per hour.

A wide range of implements can be clamped to the toolbar assembly. Basic equipment like the plow, planter, cultivator, ridger, and harrow accomplish the usual agricultural tasks while additional features such as a sprayer, circular saw, hammermill, water pump, overhead sprinkler system for up to four hectares, sawbench, and electrical generator make a useful contribution to the general chores that are needed to be done around the farm on a daily basis. As of May 1977, Tinkabi will do all this for about $2,000.

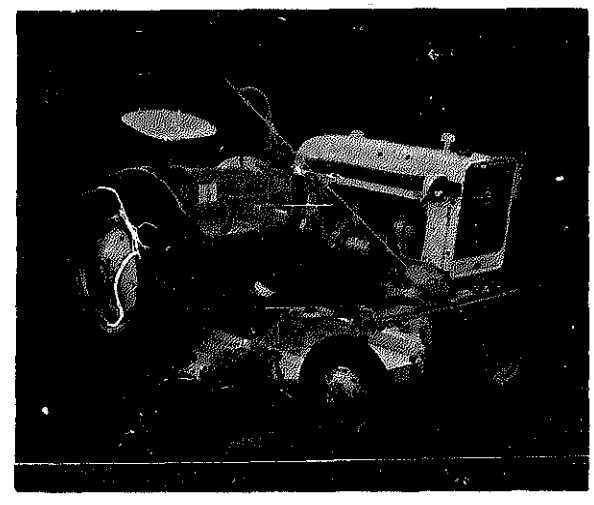


With a front loading platform and trailer, the Tinkabi can transport 2,000 kilograms. National Industrial Development Corp.

NORTH AMERICAN SOURCES OF FOUR-WHEEL TRACTORS

The International Cub Tractor

International Harvester has been making the Cub for over 25 years. It started out as an all-purpose farm tractor but has since gained popularity as a versatile implement for commercial situations: warehouses, loading docks, nurseries, and small airports. It has a 15 h.p., four-cylinder engine and hydraulic power for front-, rear-, and center-mounted implements. The offset front motor mounting improves visibility for front- and center-mounted work. The one-point fast hitch acts as a swinging drawbar to hitch or switch implements in a minute or less. The power take-off can be operated at three speeds to run a number of different implements



The International Harvester Cub International Harvester Co.

with different power and speed requirements. Attachments available with the Cub include moldboard plow, cultivators, discs, earth and snowplows, rotary and sickle bar mowers. The Cub is also available as a compact model with an 18.5 h.p. engine. With lower clearance than the standard Cub, this unit is better suited for lawn and estate work.

International Farmall 140 Tractor

Capable of mounting attachments at the front, center, and rear, the Farmall is used most with front and center cultivation to take full advantage of the Culti-Vision feature, also available on the Cub. With no blind spot in front, you can see the ground rigs on both sides of a single row and control them precisely both horizontally and vertically. This tractor is widely used for cultivating tobacco, vegetables, and nursery stock. One size larger than the Cub, the Farmall employs a 25 h.p., four-cycle, water-cooled engine with four forward and one reverse gear.

International Harvester Co.
401 N. Michigan Ave.
Chicago, IL 60611

Power King Tractors

Power King, formerly known as Economy tractors, offers several models. Differing only in features—tire sizes and type of hitch—Power King tractors put a 14 h.p., four-cycle, air-cooled, gasoline engine to operate equipment for all sorts of tasks. A belt-driven power take-off on the front of the tractor operates the mower, tiller, and snowblower while the three-groove pulley behind the engine drives the sprayer and hydraulic systems. Other attachments include a full line of cultivating equipment: spring-tooth cultivator, heavy-duty cultivator, toolbar hiller-furrower, and rotary tiller, as well as a 5-foot sickle bar, trailer, sprayer, and seed-fertilizer spreader.



A Power King tractor with rotary tiller attachment.
Engineering Products Co.

Engineering Products Co.
P.O. Box 284
1515 E. Ellis St.
Waukesha, WI 53186

Ford 1600

Ford's smallest tractor outside of the lawn and garden category is their Model 1600 with a 23 h.p. diesel engine. With nine speeds forward and three reverse and many modern features, this unit transcends simplicity but is special because diesel tractors are not commonly found in the United States. This unit has attachments for many farm jobs: there are subsoilers, cultivators, harrows, mowers, rakes, scoops, cranes, post-hole diggers, loaders, seeders, and fertilizer attachments.

Ford Motor Co., Tractor & Implement Operation
2500 E. Maple Rd.
Troy, MI 48084



Ford Model 1600

Wheel Horse Series D

The 16 and 19.9 h.p. Wheel Horse tractors would fall into the lawn and garden category except for the fact that they offer a wide variety of attachments, making them more of a utility tool than an implement for lawn care. Some of the attachments include a 3-gallons-per-minute sprayer, log splitter, landscaping rake, rear-mounted garden blade, shredder-grinder, 4-foot side-mounted sickle bar, lug wheels, mowers, cab, and all Brinly-Hardy cultivating attachments.

Wheel Horse
515 W. Ireland Rd.
South Bend, IN 46614

Magnatrac

To date, Magnatrac is the only small-scale full-track crawler we have seen. The enclosed and protected tracking system with side panels and center idler wheels features No. A550 chain welded to 10-gauge interlocking steel shoes with over 10,000 pounds of ultimate track strength, and dual track tension springs for approximately 3,000 pounds of tension maintained on each track. The all-gear transmission with four forward and one reverse speed shifts like an automobile. It is powered by a 16 h.p., valve-in-head, cool-running, cast-iron (or 12 h.p. standard) engine. It can utilize over 30 attachments including the whole Brinly-Hardy line of farm and garden implements, both high- and low-lift loaders with either hydraulic or electric lift systems, a 42-inch snow and soil blade, a 42-inch snowblower, self-dumping bucket, 36-inch-wide manure fork, backhoe, and electric light kit.

Struck Corp.
Struck Lane
Cedarburg, WI 53012

Hefty-F and LNT

The Hefty-F is an all-chore power tractor with a 27 h.p., water-cooled, four-stroke, four-cylinder, gasoline engine with diesel option. A selective sliding gear transmission operates six speeds forward and one reverse for a maximum traveling speed of 8.5 mph forward. It has a live power take-off shaft at the rear of the tractor, a ground clearance of 19½ inches, weighs 2,200 pounds and has a 12-volt starter and generator and four sealed-beam headlights. Sharing the same specifications, the Hefty LNT incorporates the same components into a compact design for narrow nursery work. Its 38-inch overall tractor width is adjustable to 56 inches. An optional creeper gear unit is available to reduce ground speed to as low as 2/10 mph for transplanting and for extra slow ground speed work. Optional implements include a 60-inch, midmount rotary



The Hefty-LNT
Diana Branch

mower, front-end loader, front-mounted snowblower, and all attachments accommodated by category I, three-point hitches. Examples include chisel plows, one- and two-bottom plows, disc harrows, six-inch blades, one-row cultivators, field cultivators, 60-inch rotary tillers and a 60-inch rotary broom.

Hefty Tractor Co.
P.O. Box 188
Juneau, WI 53039

CPI Model AY

Custom Products makes a 14 h.p. tractor with a four-cycle, air-cooled, manual start engine. It comes with four forward and one reverse speed and has a steel channel frame with 60-inch wheelbase and 14½ inches of ground clearance. As optional equipment, the Model AY is available with head and tail lights, a hydraulic power take-off system with three-point hitch which operates the lift and all other tools requiring power. Accessories include a 50-inch rotary mower, snowblower, 54-inch rear leveling blade, a 44-inch, 16-bladed, double-disc harrow, six-sweep cultivator, rotary tiller, 12-inch single-row ridger, single-row planter, fertilizer hopper, transplanter, and tilt-top cargo trailer. Weight: 905 pounds.

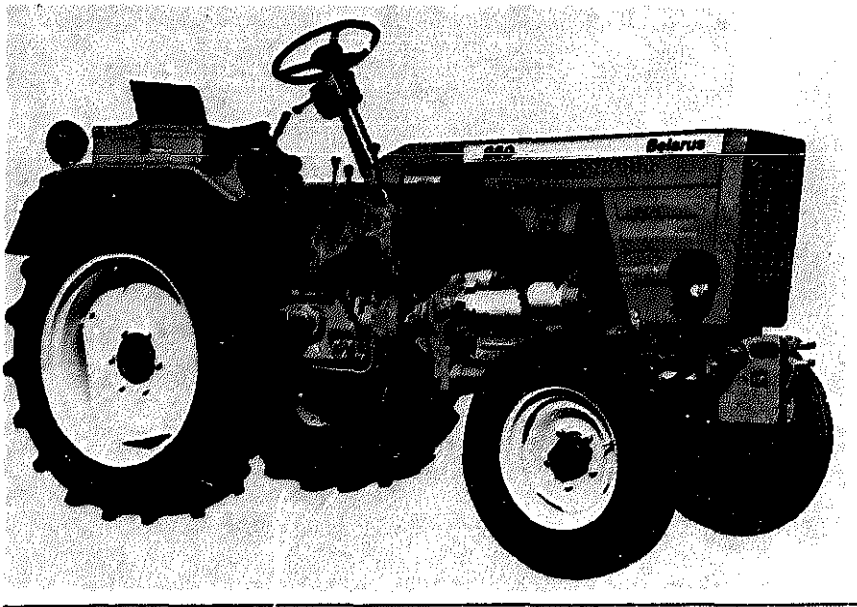
Custom Products, Inc.
4232 Roosevelt Rd.
Stevensville, MI 49127

Belarus Model 250

Another air-cooled, four-stroke diesel tractor similar in size to the Ford 1600 is the Belarus 250. It has a standard three-point hitch with drawbar, rear PTO and side-mounted power shaft, eight forward and six reverse speeds. A full line of attachments and larger units is available.

Belarus Equipment of Canada, Ltd.
43 Goldthorne Ave.
Toronto, Ontario, M8Z 557 Canada

Belarus Machinery, Inc.
7075 W. Parkland Court
Milwaukee, WI 53223



The Belarus 250
Belarus Machinery, Inc.

NORTH AMERICAN SOURCES OF GARDEN TRACTORS

There are literally dozens of lawn and garden tractors which are available with attachments in North America for all kinds of large gardening and small farming tasks. Because they do not fall in the hard-to-find category we believe it will be sufficient to provide just a listing of manufacturers and their addresses. Con-

tact a few of these sources. You'll be amazed at the attachments available.

Agway, Inc.
P.O. Box 1333
Syracuse, NY 13201

Allis-Chalmers
Box 512
Milwaukee, WI 53201

Ariens Co.
655 W. Ryan St.
Brillion, WI 54110

Avco New Idea
420 S. First St.
Coldwater, OH 45828

Belknap, Inc.
P.O. Box 28
Louisville, KY 40201

J. I. Case Co.
Outdoor Power Equipment Div.
Winneconne, WI 54986

Central Tractor, dist. by Weaver's Hardware Co.
RD 2, Lyons Rd.
Fleetwood, PA 19522

John Deere
Moline, IL 61265

Farm & Fleet
1600 E. Lincoln Hwy.
DeKalb, IL 60115

Farnam Sunrise Equipment and Supplies
P.O. Box 12068
Omaha, NE 68112

FMC Corp.
Outdoor Power Equipment Div.
215 S. Park St.
Port Washington, WI 53074

Ford Tractors
Ford Tractors Operations
2500 E. Maple Rd.
Troy, MI 48084

Gilson Brothers Co.
Box 152
Plymouth, WI 53073

or

3325 Orlando Drive
Mississauga, Ontario, Canada

Glen-Bel's Country Store
Rt. 5, Box 390
Crossville, TN 38555

International Harvester
Agricultural Equipment Div.
401 N. Michigan Ave.
Chicago, IL 60611

Massey Ferguson, Inc.
1901 Bell Ave.
Des Moines, IA 50315

Montgomery Ward
1000 S. Monroe St.
Baltimore, MD 21232

MTD Products, Inc.
5389 W. 130th St.
P.O. Box 2741
Cleveland, OH 44111

Roper Sales
1905 W. Court St.
Kankakee, IL 60901

Satoh
P.O. Box 5020
New York, NY 10022

Sears Farm and Ranch Catalog

Simplicity Manufacturing Co., Ltd.
500 N. Spring St.
Port Washington, WI 53074

Tractor Supply Co.
7910 L St.
Omaha, NE 68127

Wheelhorse
515 W. Ireland Rd.
South Bend, IN 46614

and your local hardware store.

INTERNATIONAL SOURCES OF FOUR-WHEEL TRACTORS

Finally realizing a market for the small utility farm tractor, many North American companies are distributing European and Far Eastern tractors, although they have not themselves undertaken to manufacture them. Those models readily available in North America but not manufactured there will be listed first.

Many of the larger agricultural machinery manufacturers in the United States, like John Deere and Massey Ferguson, are in the process of establishing arrangements with foreign manufacturers to build small tractors to their own specifications. As of fall 1977, arrangements were still being formalized.

The Holder Model A-18 Tractor

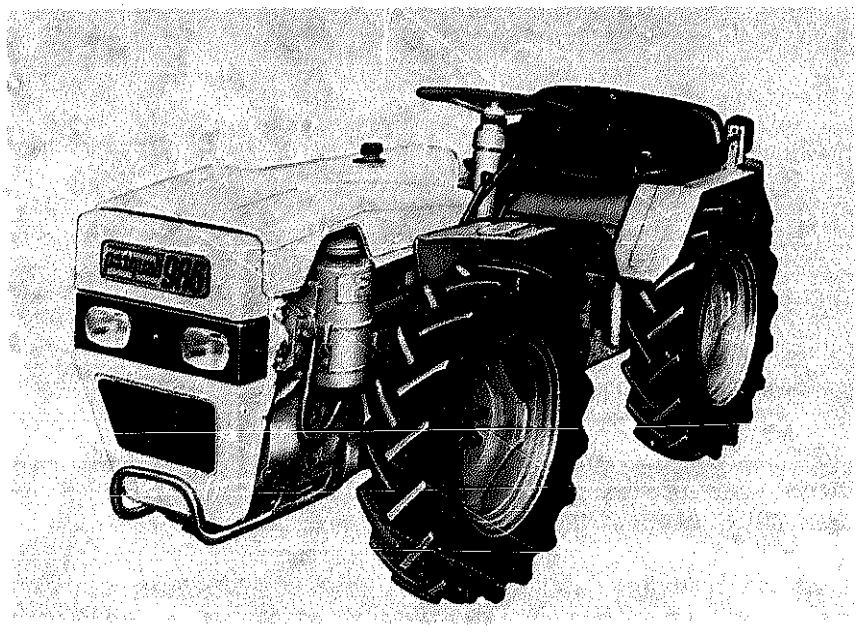
The Model A-18 was designed by the Gebruder Holder Company in Germany for use on hilly vineyard terrain, tree plantations, nurseries, berry farms—any situation requiring the combined features of maneuverability, stability, and power in a compact unit to operate in high-density plantings. Its 18 h.p., four-stroke, air-cooled, diesel engine claims to have the power of a 25 or 30 h.p. gasoline engine while consuming 1/8 the amount of fuel or less. Model A-18 comes with a standard three-point hitch and has the unusual feature of articulated, bends-in-the-middle, steering. Attachments available include a 31- or 39-inch rotary cultivator, an implement linkage for steep vertical lift, a universal implement carrier frame for plow and cultivating blades, a sickle bar, trailed spindle gang mowers, rollers, a trailer, seed and fertilizer spreaders, all varieties of rakes, and miscellaneous lawn equipment. Larger units are available.

Gebruder Holder
7418 Metzingen-Wurtt.
Postfach 66
West Germany

Tradewinds, Inc.
P.O. Box 1191
2339 Tacoma Ave. S
Tacoma, WA 98401

Pasquali U.S.A.

The Italian-built Pasquali is a 19.9 h.p. one-cylinder, four-wheel-drive, four-stroke, diesel tractor with articulated steering. Models with 24, 29 and 34 h.p. are also available. The transmission employs a sliding-type key gear with synchronizer supplying nine forward and three reverse speeds. The PTO has two speeds but it



Pasquali Four-Wheel-Drive Tractor
Pasquali U.S.A., Inc.

can also be synchronized with all tractor speeds. Supplied with both a two- and three-point linkage, the hitches can be raised with an independent hydraulic lift system. Implements available for use with the GBT Pasquali include a rotary tiller, front-mount mower, single- and double-bottom plows, cultivator, and side cycle mower. Pasquali offers a number of other PTO attachments—enough to fill a 200-page blooklet. These are discussed in the section on two-wheel tractors.

Pasquali Macchine Agricole
Via Nuovo, 30
Calenzano (Firenze), Italy

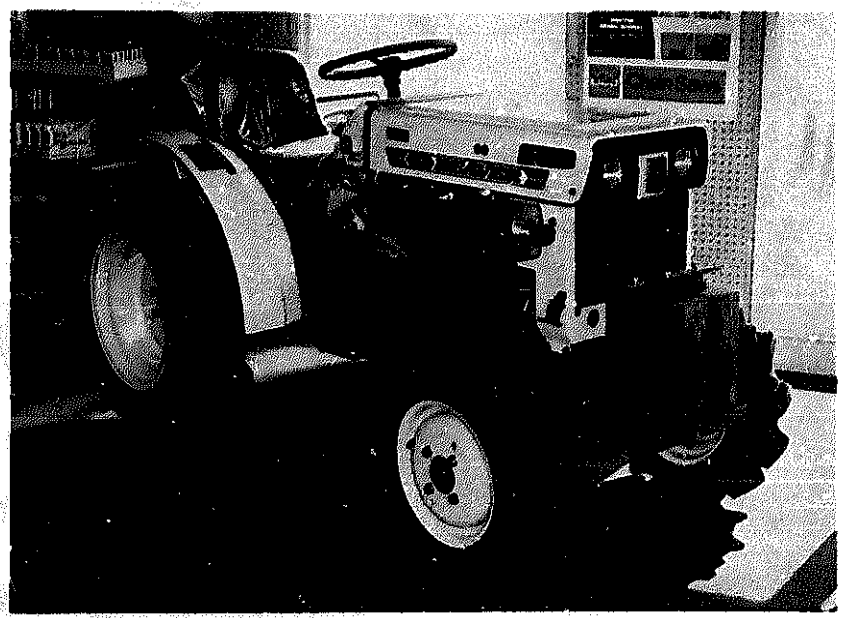
Pasquali USA
Verona, WI 53593

Satoh Beaver

The 15 h.p. Beaver is made in Japan. It has a two-cylinder, water-cooled, four-cycle, diesel engine and is available with either two- or four-wheel drive. A sliding selective gear transmission system offers six forward and two reverse speeds with a maximum speed of 7 mph. A power take-off shaft, live hydraulics, category 0 three-point hitch, sealed brakes, various warning lights, full lighting, and choice of tire tread are all standard. Optional equipment includes front chassis, front and rear wheel weights, rotary tiller with special two-point hitch, front power take-off, power take-off adaptor with guard, and hydraulic external adaptor plate. All standard category 0 implements can be fitted to this unit.

Satoh
P.O. Box 5020
New York, NY 10022

Satoh Agricultural Machine Mfg. Co., Ltd.
Hibiya Kokusai Building
2-chome, Uchisaiwai-Cho
Chiyoda-ku, Tokyo, Japan

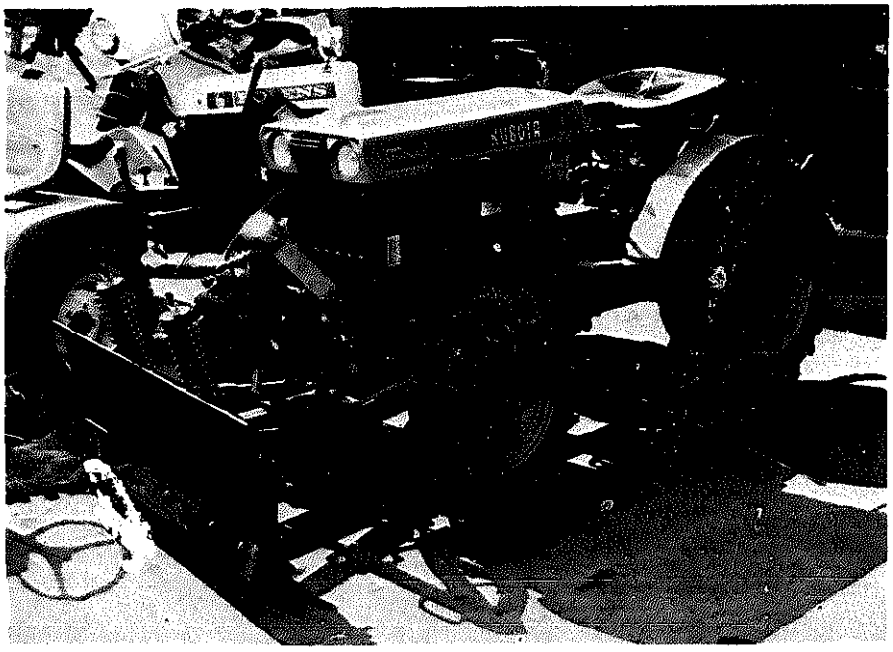


Satoh Beaver

Kubota Models B6000, L175, L225, L285

Kubota offers four basic models, and variations, of two-, three-, and four-cylinder, liquid-cooled, diesel tractors with power output ranging from 12½ to 30 h.p. The three-point hitch fits all category one implements, and the PTO is located front, center, and rear with a ten-speed multirange transmission. Units are available with four-wheel drive and lug tire options. Kubota is made in Japan but dealerships are being widely established.

Kubota Ltd.
22 Funade-cho
2-chome Naniwa-ku
Osaka, Japan



Kubota Model B6000

Kubota Tractor Corp.
300 W. Carob St.
Compton, CA 90220

Yanmar

Another compact diesel tractor available with either two- or four-wheel drive, is the Japanese-built Yanmar. The engine has two cylinders, is water-cooled, and is a four-cycle unit available in either 13, 15 or 20 h.p. models. The constant-mesh/selective mesh gear combination provides six forward and two reverse speeds. A two-speed PTO accompanies the three-point category 0 hitch with hydraulic lift. The Yanmar can be operated with a rotary mower capable of covering 1½ acres per hour, a front-end loader and backhoe for the 20 h.p. model, a 30- or 42-inch rear-mount tiller (depending on the size of the tractor), and a full line of cultivation attachments—tandem disc harrow, moldboard plow, and one-row cultivators with either rigid or six Danish vibrating S shanks. Attachments are available through the Yanmar dealers but are not exclusive to Yanmar.

Yanmar National Sales Manager
Time-Life Building
303 E. Ohio St.
Chicago, IL 60611

Yanmar Diesel Engine Co., Ltd.
1-11-1, Marunouchi. Chiyoda-ku
Tokyo, Japan

Agrale Model 4100

A four-stroke, diesel, 16 h.p., air-cooled engine powers a seven forward and three reverse speed transmission, differential lock dry plate, spring-loaded clutch, and a power take-off with three engine speeds. The unit has a working weight of 1,100 kilograms, a ground clearance of 12 inches, and a 48-inch wheelbase. It has a hydraulic lifting system coupled directly with the front power take-off of the engine, governed by a controlling three-stage lever. Implements include a two-row seed and fertilizer drill, leveling blade, cargo transporter, coffee cultivator, cultivating harrow, and three-bottom moldboard plow.

Agrale S.A.
Rua Sinimbu, 1260
Caixa Postal, 1311
95.100 Caxias Do Sul, RS, Brazil

Iseki TX1300

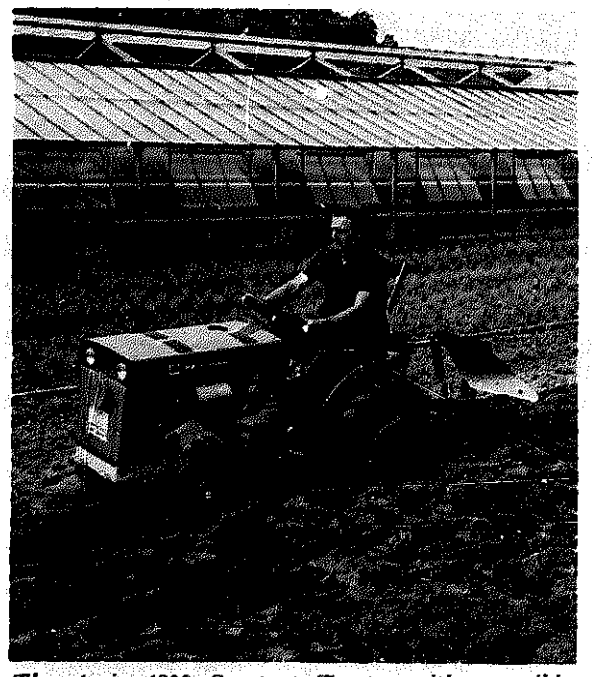
Similar in design to the Kubota is the water-cooled, diesel Iseki. It has nine forward and three reverse speeds, three speeds on the PTO,

and a hydraulic lift. Units with four-wheel drive are available, an important feature in small tractors. Often, a small tractor falls short in tractive ability before it runs out of power. Four-wheel drive increases traction by 50 percent, according to Iseki. A wide range of attachments is available for fertilizing, planting, ridging, puddling (rice culture in wetlands), mowing, tedding, mulching, and plowing.

Iseki Agricultural Machinery Mfg. Co., Ltd.
Overseas Dept.
1-3 Nihonbashi, 2-chome
Chou-ku, Tokyo, Japan

Agria 4800 Compact Tractor

Though universally applicable, the 4800 is designed to fill the gap between the range of operation of the two-wheel tractor and the commensurable four-wheel tractor in agriculture, nurseries, orchards, and vineyards. It is powered by a 19 h.p., air-cooled, four-stroke, single-cylinder engine with six forward and six reverse speeds, differential, and differential lock. Top speed is 10 mph. The rear power take-off is independent of gear speed. Track width is adjustable between 24.2 and 32.3 inches; its ground clearance is approximately 10 inches. Equipped with hydraulic lift and a 12-volt electrical system for starter, head and tail lights, and direction indicators. Weight: approximately 1,323 pounds. Implements and accessories include rotary tiller, wheel weights, spraying unit with its own 8 h.p., two-stroke gasoline engine with a 19.8 gallon capacity and high-pressure sprayer pumping 55 liters per minute, spring-tine cultivator adjustable from 80 to 125 centimeters, a six-disc harrow with working width of 43.4 inches, reversible plow, side reciprocating mower, four sizes of earth-boring augers, a two-part harrow with 70.8-inch working width, all-weather hood with front window, fertilizer-broadcaster in three sizes either ground-driven or driven by a power take-off connection, and 1,100-kilogram-capacity trailer. At the time of this writing Agria is seeking a distributor in North America.



The Agria 4800 Compact Tractor with reversible plow
Agria-Werke

Agria-Werke GmbH
7108 Moeckmuehl,
West Germany

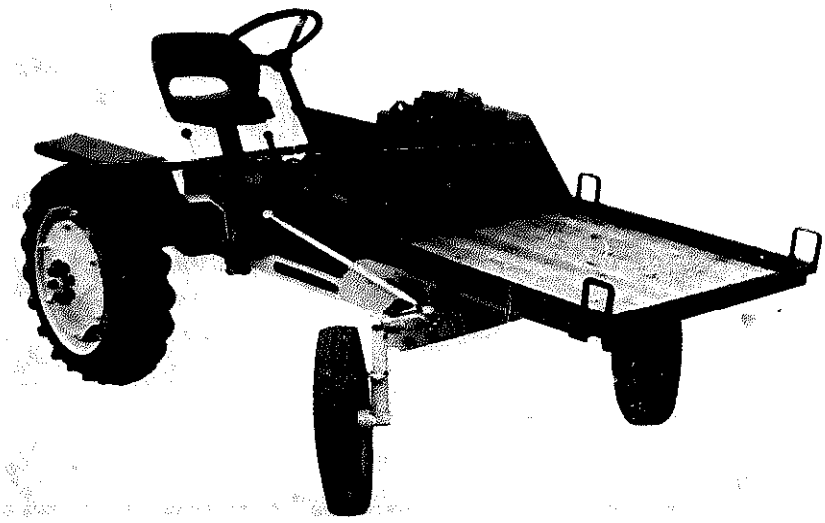
Basak-12 Garden-Type Tractor

Weighted wheels are provided with this compact, single-cylinder, 11.2 h.p. tractor. It has three forward and one reverse speed and a mechanical command lifting system with three-point linkage. Attachments include a moldboard plow with a working width of 26 centimeters and working depth of 19 centimeters, a seven-tine or three-row cultivator, ridger, duck-foot cultivator, subsoiler, and sprayer.

Turkish Agricultural Supply Organization
P.O.B. 509
Ankara, Turkey

Bouyer Tractor Type TE

Made in France, the Bouyer Type TE is a tractor built for function and simplicity. An air-cooled, diesel, four-stroke engine with either one or two cylinders, it comes in sizes varying from 14 to 20 horsepower. Wheel tread can vary from 1.410 to 1.800 meters. The V-belt transmission provides two speed ranges, high and low, for three forward speeds and one range of three reverse speeds. A wooden front platform pro-

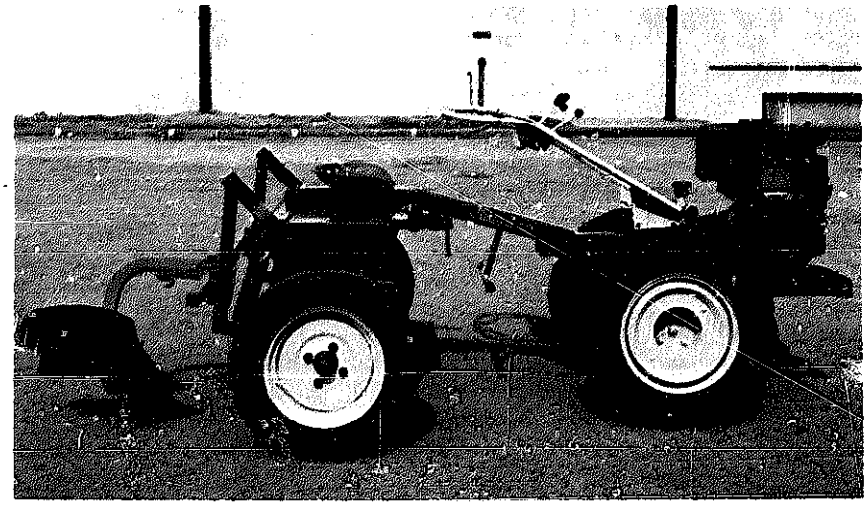


Bouyer Tractor Type TE
Bouyer

vides space for carrying a small load (500 kilograms maximum) without a trailer and provides a place for carrying extra weight in case more traction is required. The three-point hitch with hydraulic lift can be attached to a number of cultivation implements on a drawbar. A four-row seeder-fertilizer distributor is available along with a range of implements for tropical agriculture.

Bouyer Mototracteur MT-80

The MT-80 is a front-, two-wheel drive unit with articulated steering. The rear axle with seat mounting, the tropicultor, is separable from the main power unit. The front unit is powered with either an 8 or 10 h.p., air-cooled engine with special equipment for operating in tropical climates. The two-belt transmission operates a high and low range for two forward and one reverse speed. It is not clear whether or not the power section is designed for use without the tropicultor. However, it does appear that the tropicultor was designed to allow the power unit of a walking tractor to function with attachments for cultivation, plowing, and seeding larger than those of most walking tractors. It is equipped with a mechanical lifting device but no power take-off. Attachments include a subsoiler, a ten-inch moldboard plow, a spring-tooth harrow, a nine-tine chisel plow, and a three-row seeder.



Bouyer MT-80 with main power unit, tropicultor, and moldboard plow on a mechanical lift.
Bouyer

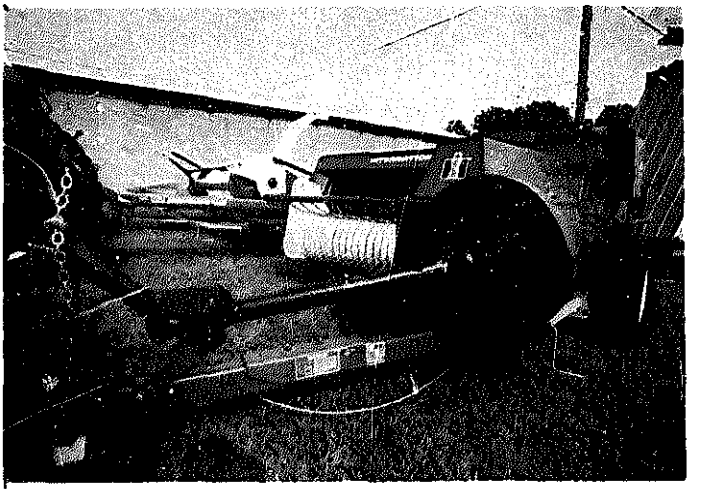
Bouyer
B.P. 23
Tomblaine 54510, France

TRACTOR ACCESSORIES

The PTO

Power supplied to farm equipment can come from the unit's own motor, a pulley drive from an independent motor, or by the power take-off shaft of a tractor. The power take-off (PTO) arrangement was introduced in the 1920s and has become the most widely utilized power source for farm work. Universal joint linkages between the tractor and implement have minimized the limitations the presence of a tractor imposes on the flexibility and maneuverability of this setup. The amount of use any one farm implement gets in a year does not usually justify the investment in a separate motor; so the PTO offers considerable savings in capital output here.





The flexible network of universal joints linking a PTO shaft to a hay baler.

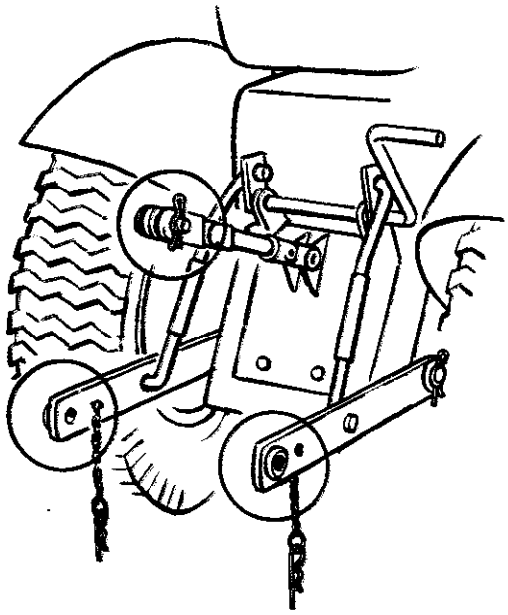
The finger points to a power-take-off shaft on an old model tractor with a pull-type hitch.

Hitches

Machinery is called either pull-type (trailing) or mounted. Pull-type tools simply hitch to the tractor drawbar and are pulled thus by the tractor. Mounted tools attach to tractors in such a way that they can be lifted entirely off the ground for easy turning or transport to and from fields. Almost all mounted tools today use the three-point hitch arrangement pioneered by Henry Ferguson on the Ford and Ferguson tractors. (The Allis-Chalmers WD and WD-45 have their own hydraulic hitch arrangement which is somewhat different from the three-point hitch and will accommodate only Allis-Chalmers machinery built for it.) The three-point hitch (by which a tool hitches to two points on the drawbar and one above) makes hitching, transport of machinery, lifting, lowering, and depth adjustments relatively easy compared to older methods. Today, three-point hitches can be purchased and fitted to almost any tractor.

Pull-type tools are not to be ignored, however. If you are willing to give up some convenience and especially if machinery does not have to be transported over the road, older implements can be used which offer a considerable saving. Three-point hitches and tools to fit them are in a higher price range than the same equipment in pull-type models.

Particularly when buying an older tractor,



Circled are the three points of attachment for a hydraulically powered lifting hitch.

a general rule to consider is to be sure that you know what equipment will or will not fit your tractor. The ideal is to buy your basic machinery—plow, disc, planter, mower, cultivator, and others—together with the tractor on which they have been mounted.

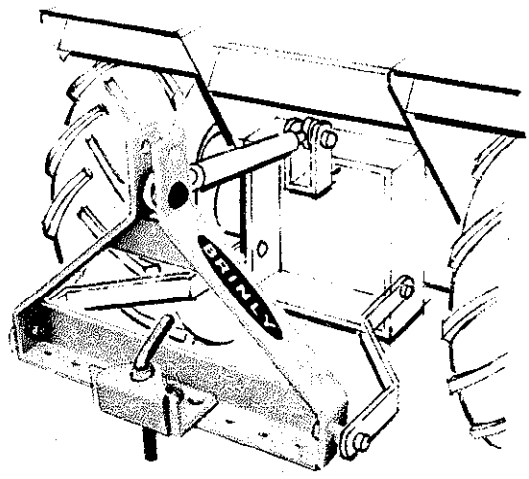
Many small tractors come equipped with three-point hydraulic lifting hitches which do not fit the many pull-type tools made for small farm and garden tractors. Brinly-Hardy makes the following adapters to convert three-point hitches into pull-type on 14 to 18 h.p., category 0 tractors.

A Frame Adapter With Sleeve Hitch

This unit was designed for adapting sleeve-type hitch implements for use on tractors equipped with category 0 three-point hitches. It is required for using Model KK-305 Planter-Fertilizer, TT-100 Toolbar and BB-363 Fork Lift Kit. Weight: 28 pounds.

Drawbar Attachment (For use with category 0 three-point hitch)

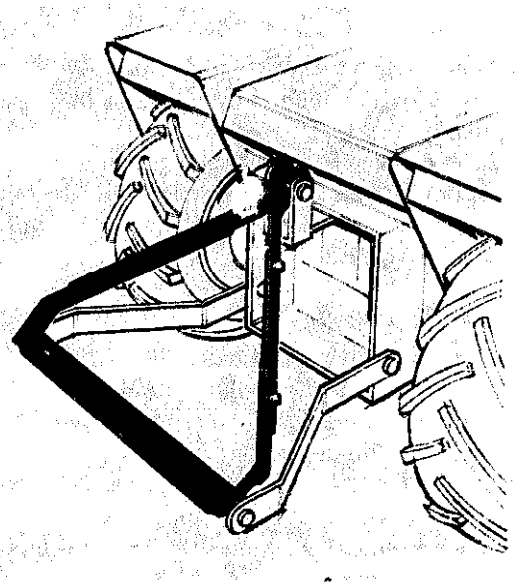
This unit includes cross-type drawbar and two adjustable support links for drawbar weight control. Use it for general-purpose trail-behind attachments. Weight: 18 pounds.



Model HH-1000 three-point A Frame Adapter with Sleeve Hitch.
Brinly-Hardy

The Toolbar

Rather than attaching each implement directly to a tractor, the toolbar allows the option of pulling many attachments at any desired spacing. When planting, both planters and fertilizer distributors can be utilized at the same time. Plantings can be made in irregularly spaced rows to make way for the tractor's tire



Model BB-370 Drawbar attachment.
Brinly-Hardy

tracks or for intercropping techniques. When cultivating, any number of chisels or sweeps can be mounted on a tool bar in any complementary combination. The tool bar also offers a savings in investment in that only a simple bar clamp is needed for the link between tool and tractor rather than separate hitching hardware, which can be especially complicated and expensive with three-point hitches.

The above three attachments are made by:
Brinly-Hardy Co., Inc.
P.O. Box 1116
Louisville, KY 40201

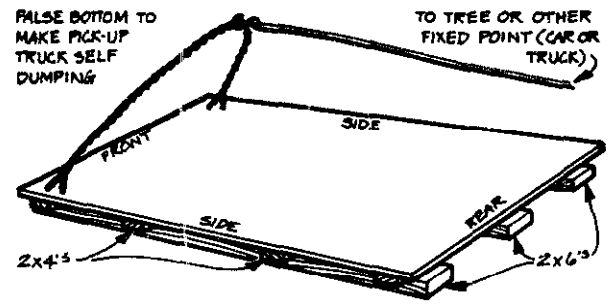
FARM TRANSPORT—CARTS AND WAGONS

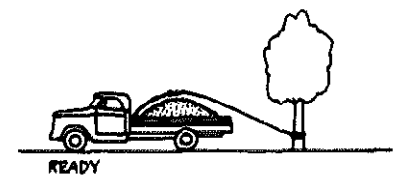
Everyone is aware of the need for a utility transport vehicle on the farm, and their availability is certainly widespread. Rather than try to list a full range of sources for this kind of tractor attachment, we have chosen simply to cite examples of what is made and offer a few build-it-yourself plans. When selecting a trailer design, here are a few points to consider.

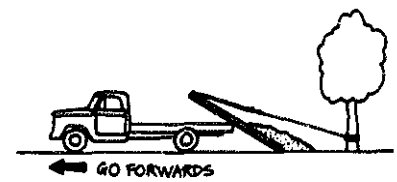
1. Capacity—both size and volume, can side extensions be added on, bought or built?
2. For hilly terrain, a long bed, low to the ground, with a wide tread is best.
3. The longer the distance between the hitch and the axle, the easier it is to back into places.
4. Do you need a trailer that can dump?
5. Match a trailer to your needs and to complement the power source pulling it with a maximum load.

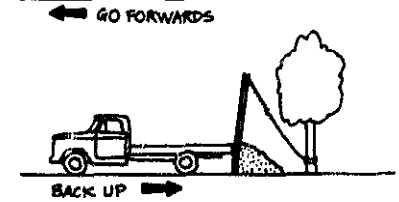
Build-It-Yourself Dumper for a Pickup Truck

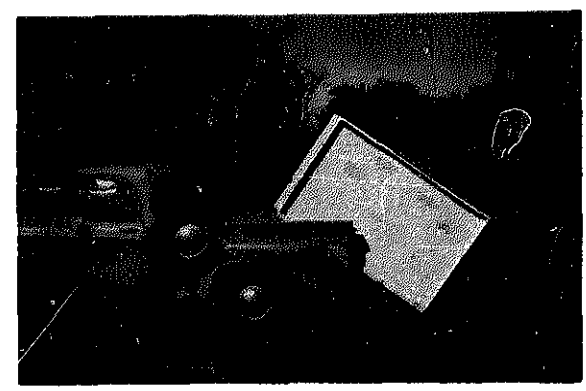
Tim Sanford of Alexander, Maine, was kind enough to send us these plans for adaptation to a pickup truck he has found useful. It simply involves building a platform to fit in the bed of a truck, but not fitted around the wheel wells. It must be free to slide out of the truck. A sturdy chain arrangement is attached to the front of the platform as illustrated, to which a fixed line will be attached. As the driver slowly goes forward, the platform and load will be neatly left behind but not in a dumping position. The driver then slowly backs up and pushes the load into a vertical position so the material slides off the platform.











You can build this dumper from the Pickup Truck Dumper Plans described in the text.
Howard S. Berg

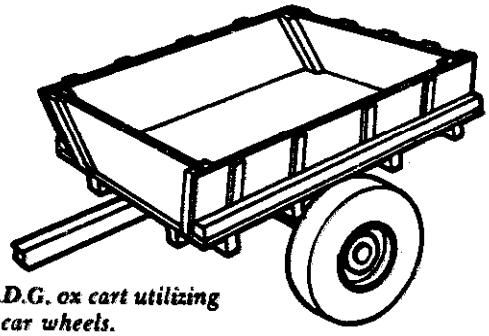
Pickup Truck Dumper Plans

Plans for a roll-out dump box are available for $3.75 (as of fall, 1977).

Howard S. Berg
3537 Concord Blvd.
Concord, CA 94519

ITDG Ox Cart Plans Utilizing Old Car Wheels

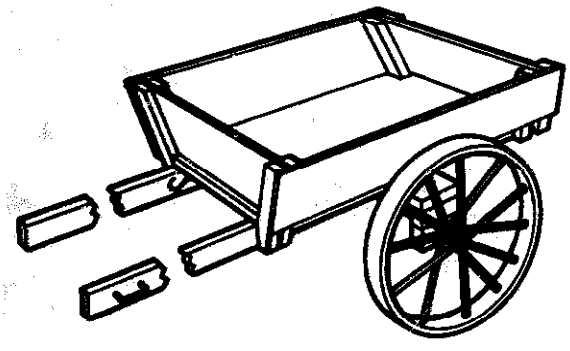
This cart uses the front wheels from an old car or lorry. Wheel mountings are cut off and welded to a box-section axle fabricated from angle iron. The cart chassis and body are constructed of wood, and all parts are bolted together.



I.T.D.G. ox cart utilizing old car wheels.

ITDG Plans for Wananchi Ox Cart

Designed to carry a load of 1,400 pounds, this cart is pulled by two oxen. The wood-block axle bearings, each made of two pieces of wood, are oil-impregnated by soaking in hot oil, and the axle bearing hold is drilled centrally through the blocks. This bearing design facilitates ease of maintenance and renewal of the bearings by carpenters in rural areas.



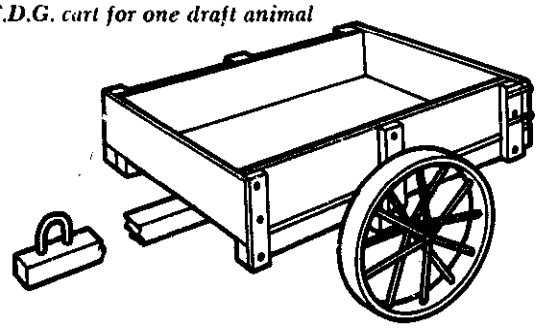
I.T.D.G. Wananchi ox cart

ITDG Cart For One Draft Animal Plans

Designed to carry a load of 1,400 pounds, cart is pulled by one donkey or an ox. The wood-block axle bearings are oil-impregnated by soaking in hot oil before drilling and assembly. Both the front and back boards of the cart body are removable. The cart shafts can be made of tubular metal pipe instead of timber for extra strength.

All the above plans are available from:
Intermediate Technology Publications, Ltd.*
9 King St.
London WC2E 8HN, England

I.T.D.G. cart for one draft animal



Tractor Carryall Plans

Plans for a nonwheeled carryall bed to be attached by a three-point hitch to a hydraulic lift system of a tractor are available for a slight charge.

VITA (Volunteers in Technical Assistance)
3206 Rhode Island Ave.
Mt. Rainer, MD 20822

Heald's Hauler

Available as a kit, this quarter-ton utility truck features large flotation tires, sturdy tubular frame, and dump bed. The large, padded seat and bed tip open for easy access to the engine. The truck is powered by either an 8 h.p. Tecumseh or a 10 h.p. Synchro-balanced Briggs & Stratton four-cycle engine. A large Comet torque converter, forward and reverse transmission, number 40 chain, and differential axle complete the drive train. Hand-operated throttle and hydraulic disc brakes are standard. Lights,

* Intermediate Technology publications can be ordered from International Scholarly Book Service, Inc., Box 555, Forest Grove, Oregon 97116



The Heald Hauler
Heald, Inc.

speedometer, knob tires, and spark arrest muffler are options. The Hauler comes in easy-to-build semikit form with all parts furnished. The engine and transmission come assembled and are mounted on the welded and painted frame. The tires are mounted on the rims, so all that is required is to bolt the various parts together using an easy-to-follow step-by-step procedure. Construction time averages 6 to 8 hours.

Heald, Inc.
Dept. DTB, P.O. Box 1148
Benton Harbor, MI 49022

Bike Barrow

The bike barrow was designed by Jay Welsh at the Foundation of Self-Sufficiency Research Center, 35 Maple Avenue, Catonsville, MD 21228 as a simple pushcart to be built from recycled materials. The three-wheeled cart, built from two discarded bicycles, two-by-fours, and plywood can be maneuvered by one or two people. Plans presented in the May 1977 issue of *Rain* magazine are available by purchasing that issue.

Rain Magazine
2270 Northwest Irving
Portland, OR 97210

Fayette Trailer Carts

Fayette offers models of wide-bottomed trailer carts 4 feet wide by 6 to 8 feet long that carry up to 1,200 pounds. Rugged wheels are designed for transport across the country or around the corner.

Fayette Mfg.
Fayette, OH 43521

Garden Way Handcart

Three sizes with a wooden body are available as kits or finished carts.



The Garden Way hand cart
Garden Way Research

Garden Way Research
Department DTB
Charlotte, VT 05445

Economy Handcart

Plans are available for a cart with large wheels which converts easily to a garden tractor dumping cart. Tips on acquiring construction parts are also provided.

Economy Designs
Box 871, Dept. DTB
East Douglas, MA 01516

Vermont Ware

Two carts are available with 300-pound capacity and metal beds.

Vermont-Ware
Dept. 702-DTB
Hinesburg, VT 05461

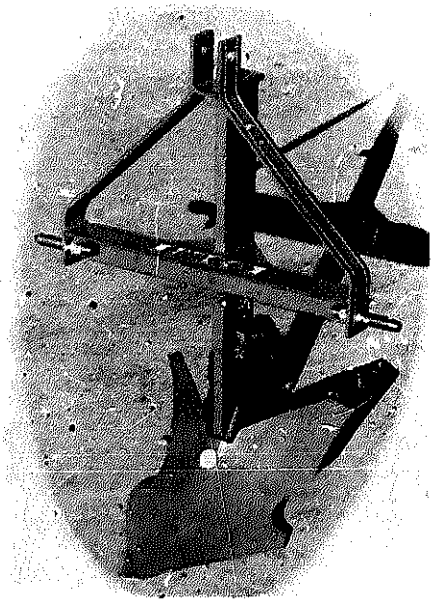
Utility Trailer

A utility trailer capable of on-the-road travel is available in three sizes, all with a 1,200-pound capacity. The utility model weighs 389 pounds, has 24-inch removable side racks and a bed sized 102 x 55 inches. The bed tilts for easy loading of equipment.

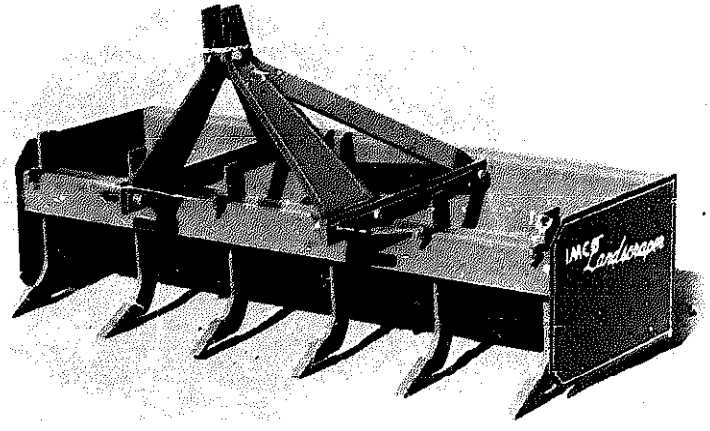
Vann Industries
Clinton, NC 28328

ASSORTED TRACTOR ATTACHMENTS

A number of tools and implements for the small farm tractor are available for miscellaneous farm tasks which do not fall comfortably under one heading. We thought it would suffice to illustrate these implements with only one representative photograph and descriptive caption since differences between manufacturer's models are slight and because often the function is quite familiar.



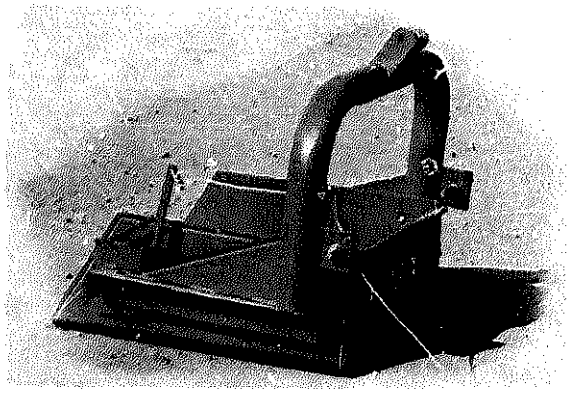
A middlebuster, designed for the large garden or small farm, gives a full 12- or 15-inch cut. Two-row models are available, and both use a standard category 1 hitch.
Independent Mfg. Co.



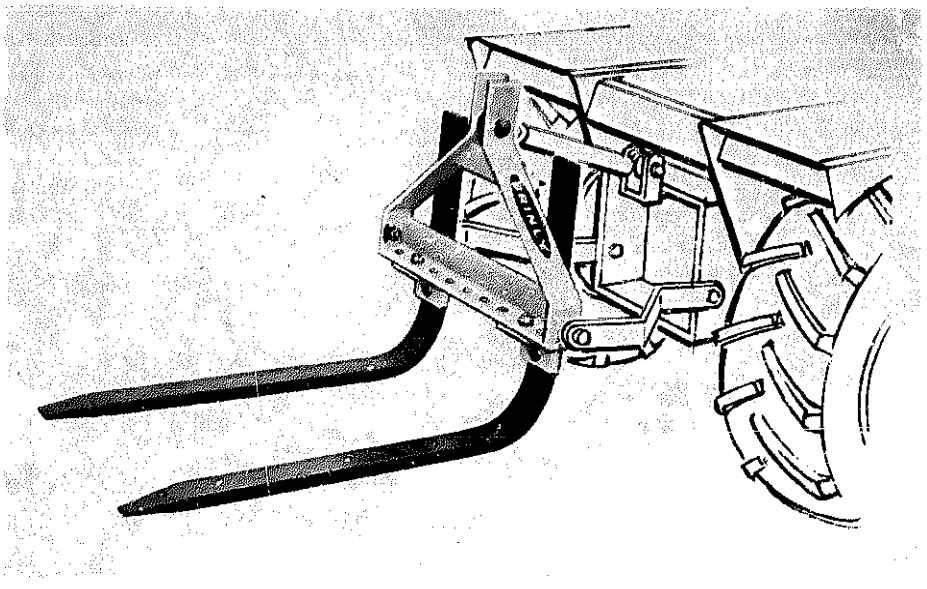
Especially of interest to nurserymen and builders, a boxscraper or land scraper with its scarifier shanks assists in leveling and grading land.
Independent Mfg. Co.



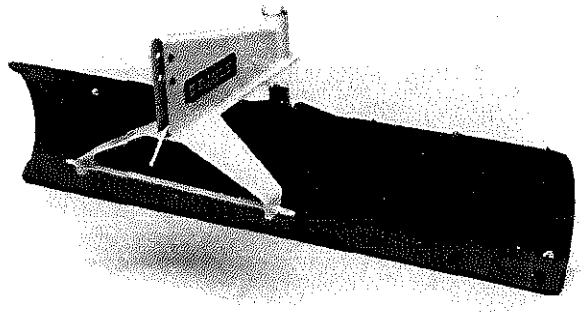
Tractor-operated post hole diggers, or augers, make quick work of digging holes in most types of soil.
Independent Mfg. Co.



Scoops, attached to a tractor with a three-point hitch, can be used for pond and ditch digging, feedlot cleaning, and moving and dumping materials on the farm.
Independent Mfg. Co.



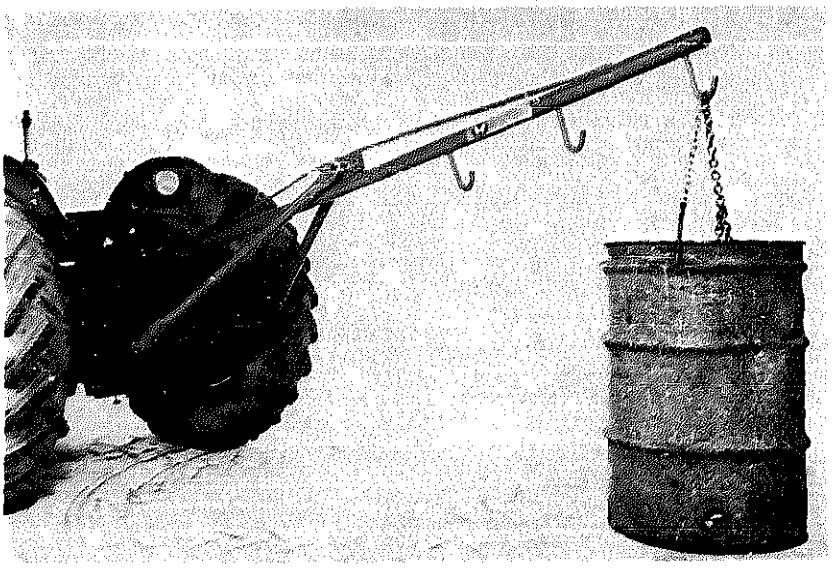
Forklifts, for lifting, hay handling, and short-haul transporting, can be valuable work savers.
Brinly-Hardy Co.



Rear blades, especially when they can be angled or reversed, can be utilized for a variety of tasks including landscaping, leveling, grading, and snow removal. **Brinly-Hardy Co.**



The Agria walking tractor with a hauling wagon, fully equipped for road travel. **Agria-Werke**



A boom crane is useful not only for lifting, but also for pulling fence posts, changing wagon tires, and even for some portions of a farm slaughtering operation. **Wikomi Manufacturing Company**

SHOULD YOU INVEST IN FOREIGN MACHINERY?

At the international level, attachments for two- and four-wheel tractors are not difficult to locate. Each manufacturer generally offers a full line of implements to fit his machinery, including even the unfamiliar power take-off tools for windrowing, harvesting, and pumping as explained in each chapter of this book. In North America, the latter are not always so easy to come by, but three companies do carry the basic tools required for plowing, cultivating, and seeding with small tractors. These include the Brinly-Hardy Co., Inc., P.O. Box 1116, Louisville, KY 40201; the Independent Mfg. Co. (IMCO), P.O. Box 300, Neodesha, KS 66757; and the Special Products Co. (SpeeCo), 15000 West 44th Ave., Golden, CO 80401. Many big-name manufacturers, who build tractors, carry a line of attachments from these smaller companies.

Europeans have all the tools they need for the small farm and they all attach to one power unit For many implements, we have found no North American counterpart, but if available at all, chances are such counterparts will have their own motors. Certainly there are advantages to having one machine running while tending another, but consolidation provides the resources to afford a huskier power unit or other attachments.

Foreign manufacturers have shown considerable interest in marketing in North America, and from our vantage point, the prognosis for getting these tools into the hands of America's small farmers looks very good.

SOURCES OF ASSORTED EQUIPMENT FOR TRACTORS

	MIDDLEBUSTERS	SCARIFIERS (LANDSCRAPER)	POST HOLE DIGGERS/ AUGERS	SCOOP	LIFTER/CARRIER	BLADES	CARTS	ROLLERS	AERATORS	BOOMS
ALLIED						X				
ARPS DIVISION OF CHROMALLOY			X							
BEAUVAIS ET ROBIN, ETS.							X	X		
BRANTLY MFG. CO.			X							
BRINLY-HARDY					X	X		X		X
CECOCO					X	X	X			
CENTRAL TRACTOR				X						X
CONTINENTAL PRODUCTS			X							
CORSICANA GRADER & MACHINE CO.	X		X	X	X	X				X
GANTT MFG. CO.				X		X				
W. HERTECANT						X		X		
IMCO (INDEPENDENT MFG. CO., INC.)	X	X	X	X		X				

"Well sure," you say, "those tools are great for European farmers who have the manufacturer next door and can get parts and service with no problem. What about small farmers in the United States who can't wait to send for a part overseas?" Taking seriously the small-scale farming market and the skepticism against investing in foreign equipment, some companies (like Kubota and Pasquali, for instance) are setting out to solve that problem. For example, the Pasquali Company in Barcelona, Italy is establishing an arm of its company in Verona, Wisconsin called Pasquali U.S.A. Instead of passing through the hands of an importer, a distributor, and a dealer, all of whom handle a variety of products, Pasquali will serve as both importer and distributor and will handle only Pasquali products. They will stock every part that would be found at the manufacturing plant in Italy, so that a dealer need only send to them for a part and be assured of the same service as if they were dealing with a Detroit manufacturer. As for service, Pasquali U.S.A. is planning a training program for its dealers right at the manufacturing plant in Barcelona.

All this is great news to the small-scale farmer. Not only does it lend credibility to foreign products as worthwhile investments in the future in North America, but it stimulates the competitive spirit in our own free-enterprise system. We have had many requests for this book from United States manufacturers who are interested in new product lines. If the market reveals itself, many will jump at the chance to satisfy it. As we mentioned earlier, John Deere, Allis-Chalmers, and Massey Ferguson are contracting to sell Japanese-made intermediate tractors under their own names.

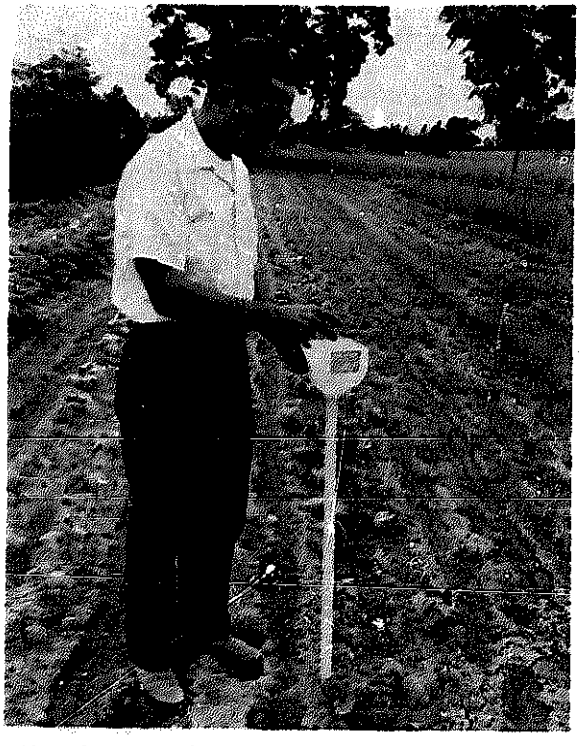
The ball is already rolling. There's no reason for this marketing approach to stop with tractors. Meanwhile, study the foreign alternatives as prospects of things to come.

	MIDDLEBUSTERS	SCARIFIERS (LANDSCRAPER)	POST HOLE DIGGERS/ AUGERS	SCOOP	LIFTER/CARRIER	BLADES	CARTS	ROLLERS	AERATORS	BOOMS
INTERNATIONAL MODERN MACHINERY, INC.		X	X			X				
K-W MFG. CO., INC.			X							
MONTGOMERY WARD				X						
PENGO CORP.			X							
PIERCE OF WEXFORD						X				
SEARS, ROEBUCK & CO.			X	X	X	X				X
SOUTHEAST MFG. CO.				X	X					X
SPEECO (SPECIAL PRODUCTS)						X				
TRACTOR SUPPLY CO.			X	X	X	X				X
THE VASSAR CO.		X	X	X		X				X
WIKOMI MFG. CO.				X		X				X

-5- Equipment for Seeding and Planting

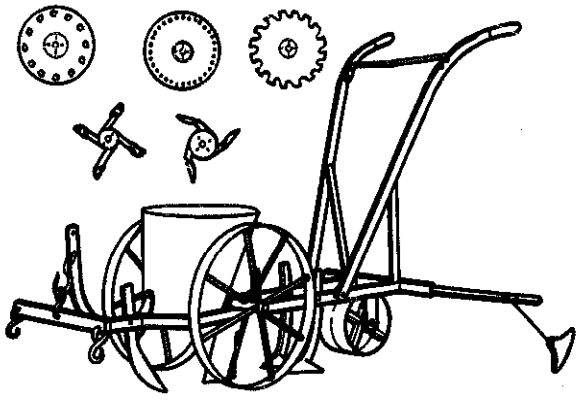
The simplest hand-operated planters are the walking stick type, most suitable for planting seeds at wide spacings or for interplanting. They can be used in quite rough seedbeds so long as the ground is soft enough for the stick to be inserted.

A hand-pushed, wheeled seeder normally requires a well-prepared seedbed for easy penetration and uniform placement of seed as well as ease of operation. Two or more of these seeder units may sometimes be mounted on an animal-drawn tool bar.



After hours of back-bending labor, Don Green, a Michigan gardener, decided there was an easier way to put his seeds in place—to make an extension of his hand. Using the top part of a ½-gallon plastic container and a plastic tube used in a golf bag to protect the club shafts, he created a seed funnel. Total cost was 18 cents, and his device can be used to place rock fertilizers or shrubs or garden plants too.

The simplest animal-drawn seeders consist of a cultivator-type tine carrying a tube through which seeds are dropped by hand. These implements ensure that the seeds are sown in lines at approximately constant depth, but the spacing along and between the rows depends entirely on the operator's skill. Single-row and multirow versions are available. Most units are fitted with a reversible, adjustable marker.



Animal-drawn planter with mechanical seed-metering plates.

Animal-drawn seeders with mechanical seed metering are of two types.

1. Those planting several rows at close spacing are commonly used for grain crops in humid or irrigated areas.
2. Single-row machines are generally used to space seeds at wide intervals in drier areas.

Various mechanical seed-metering systems are used. A rotating brush or agitator controlling the flow of seed through an adjustable opening will handle most types of seeds with minimal damage, as will contrarotating soft rollers, but these mechanisms do not closely control seed spacing in the row. Fluted roller feed mechanisms give more accurate control of the overall seed rate per hectare but, again, do not control

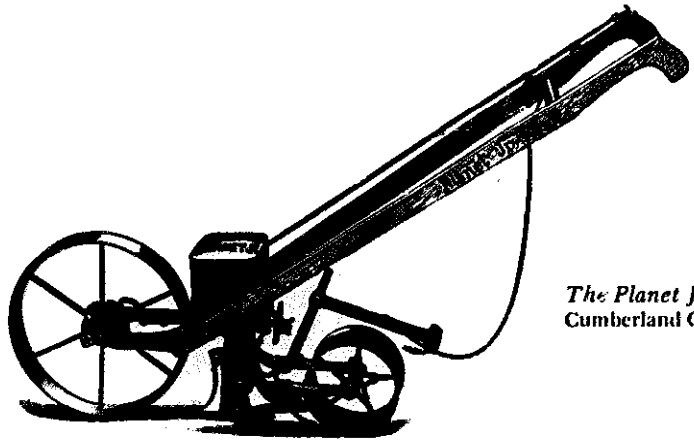
spacing in the row. Cell-wheel and perforated belt-metering systems can give very precise spacing of seeds, particularly those which are approximately spherical in shape. The metal cell wheel is more likely to cause damage to delicate seeds than the flexible perforated belt. Some seeders can be adjusted to plant bunches of seeds at wide spacings.

Many animal-drawn seed drills can also place fertilizers close to the seeds, where they may be more effective. Specialized fertilizer-spreading equipment is available.*

SEEDING

by Rob Johnston

To plant large seeds in large amounts, we generally use our two-row corn planter. However, most of our crops are small seeded, or planted in pieces too small to make setting up a corn planter practical. The implement which really comes in handy is our Planet Junior Number 300-A seeder. Planet Junior has been making hand garden implements for over 100 years, and the models have hardly changed. The 300-A has been made since the 1920s, and the current unit is nearly identical to the first ones made.



The Planet Jr. 300-A Seeder.
Cumberland General Store

We seed lettuce, beans, and everything in between. We could do just as good a job seeding by hand, but this is where the weather sets the rules. Here in Maine, considering the crops we're growing, we have to take full advantage of days with good planting weather. We might sow four crops with the hand seeder where we would have time to sow only one by hand. The unit is made of cast iron and steel and has enough weight (over 40 pounds) to roll with good momentum. Anyone who has tried to push a plastic seeder on less-than-perfect soil can appreciate this feature.

The seeding mechanism of the 300-A is simple. A small, fluted, feed wheel inside the hopper pushes the seed through a hole in the stationary seed plate; the seed falls into the furrow made with the depth-adjustable opening plow, is covered with a down-pressure-adjustable coverer, and firmed with a concave, rear packing wheel which leaves a slight ridge over the seed for easy sprout penetration. When changing from one seed to another or varying the spacing at which the seed is dropped, the seed plate hole size is changed (there are 39 different holes from which to choose).

Of course, we do a lot of seeding by hand, especially for our trials, where we may have 200 10- or 15-foot rows in a single trial. The time it takes to empty and refill the hopper on the Planet Junior seeder is impractical on these short rows of many different varieties. However, we often use the seeder to make rows for hand planting.

* Reprinted with permission from *Tools for Agriculture: A Buyer's Guide to Low Cost Agricultural Implements*, by John Boyd (London: Intermediate Technology Publications, Ltd.).

For the first row, we stretch a line between stakes and run the seeder along this line. The seeder has an adjustable row marker which marks the next row, so if we get the first row straight (easy when using a tight line), all the other rows in the planting will be straight too.

To make the furrows prior to hand sowing we use our Planet Junior garden plow, one of the high-wheel types that you find almost everywhere, which are made by numerous companies. I'm not sure about the other brands, but ours comes with three different-sized furrows. For large seed such as peas and potatoes, we use the moldboard plow attachment. After sowing the seed, the plow is run first down one side of the furrow, then back in the opposite direction down the other side, closing the furrow and covering the seed neatly and very quickly. It is certainly a whole lot faster than using a hand hoe. For small seeds such as carrots, we use the small cultivator tooth on the high-wheel plow and then cover the seed by hand during sowing.

HAND-OPERATED JAB PLANTERS



A hand-operated jab planter.

For at least a century, most of the corn in this country was planted with jab planters. Two variations on the same idea were built, but both of them are basically glorified dibble sticks. The lower steel blade of the planter was jabbed into the ground, and then, by moving the handles, three or four kernels of corn were dropped from the planting box through a planting tube into the ground opened up by the blades. When the point of the planter was pulled out of the ground, the dirt fell around the seed.

Even after these planters were more or less obsolete, farmers used them to replant hills of



Gene Logsdon demonstrating the use of the jab planter.

corn skipped by the horse-drawn planter.

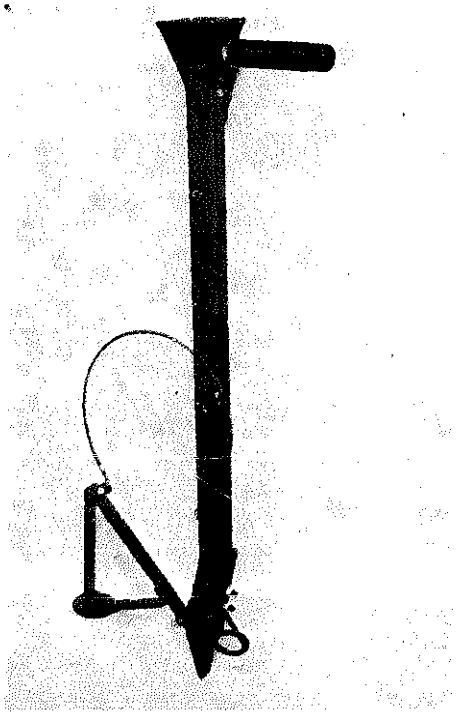
Today, a jab planter can come in handy for interplanting. For example, if you have a row of corn up and growing and want to plant pole beans beside the cornstalks, the hand planter is just what you need. You can walk along the row, plant the seeds where you will, and not disturb the soil around the already growing corn.

Fancy new models of the jab planter are still available and are used in research plot planting. They are available from manufacturers and suppliers of seed industry equipment. Old, used jab planters are often available at farm sales. You might pay $5 for one, or you might pay $35—you can never tell at an auction.

NORTH AMERICAN SOURCES OF HAND PLANTERS

Jab-Type Hand Planter

The Allan Machine Company has three models of jab planters which are hand fed, spring operated, have a metal barrel, and will adjust to different planting depths.



ALMACO Slim-Style Jab Planter model SHP-NBA
Allan Machine Co.

Model SHP-NBA

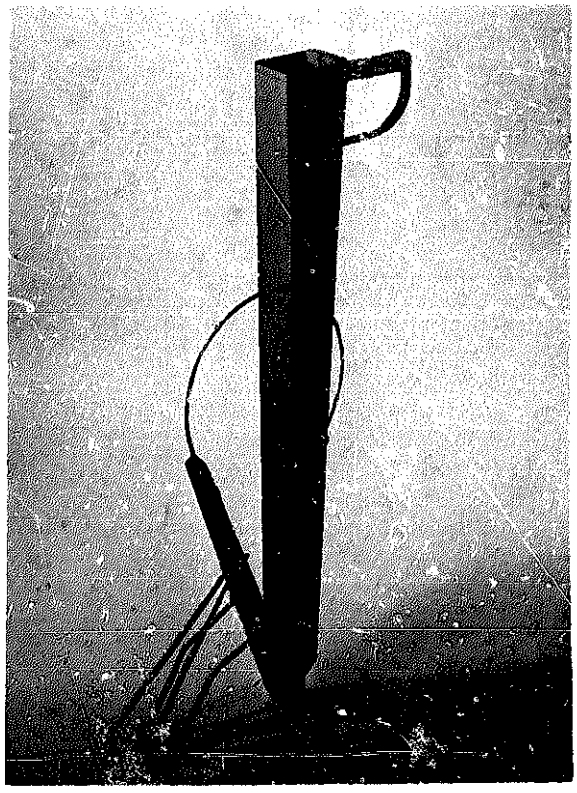
This is a slim-style unit and has a narrow, single barrel weighing 4½ pounds with a 1⅜-inch by ⅞-inch barrel opening.

Model HP-SBA

This is a single-barrel model which weighs 4 pounds and has a wooden back and a barrel opening of 2½ inches by 3 inches at the top.

Model HP-DBA

The third model has a double- or divided-barrel style and comes with a wood back.



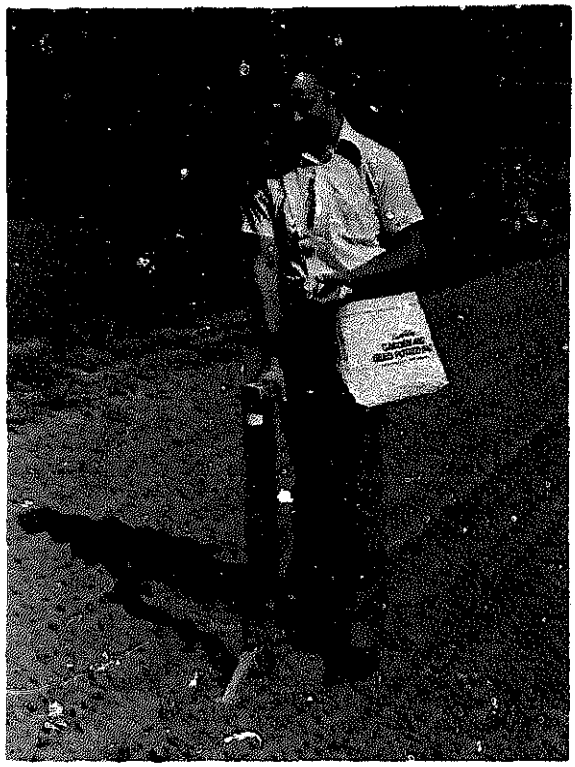
ALMACO Single-Barrel Jab Planter model HP-SBA
Allan Machine Co.

Allan Machine Co.
P.O. Box 112
Ames, IA 50010

Potato Planter

Made of lightweight, corrosion-resistant ma-

terials, this unit plants potatoes at adjustable depths. It has a one-year guarantee.



Hand jab potato planter.
Esmay Products, Inc.

Esmay Products, Inc.
P.O. Box 547, Maple St.
Bristol, IN 46507

Jab-Type Hand Planter

Burrows offers two models, both made of sheet metal and hardwoods. A spring-operated, planting depth adjustment is provided. The 4-pound units are approximately 33 inches high and have an opening 2½ inches by 3 inches at the top of the barrel.

Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204

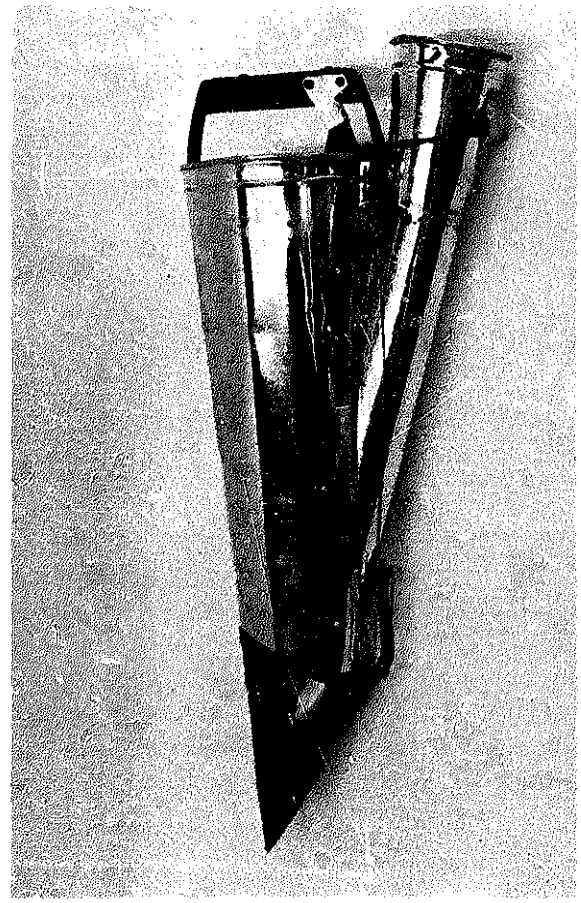
Maquinas Agricolas
Avenida Brazil No. 232
Marilia, Brazil

The Plantmaster

To operate the plantmaster, you select one of a range of seed-metering discs according to the seed size, adjust the foot, place the unit on the soil, and depress the handle. A seed is automatically inserted into the soil. Up to 2,500 seeds can be planted per hour at a depth between 6 and 66 millimeters.

Vandermolen Corp.
119 Dorsa Ave.
Livingston, NJ 07039

Richmond Gibson, Ltd.
Salisbury Rd., Downtown Salisbury
Wiltshire, U.K.



The Cumberland Plant Setter
Cumberland General Store

Cumberland Plant Setter

The Cumberland Plant Setter is a heavy

tin tank with a chute grooved and soldered to assure sturdy construction. High-carbon steel shovels with large, curved flanges rake the earth over the roots. It sets, waters, and covers tomato, tobacco, pepper, cabbage, sweet potato, strawberry, and other slip plants in one operation. Shipping weight is 12 pounds, height is 30 inches, and the diameter of the funnel chute is 4½ inches.

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

INTERNATIONAL SOURCES OF JAB PLANTERS

Hand Maize Planter

A single seed is placed in the soil automatically when the stick is inserted. It can be used with one hand and is suitable for small cultivation or experimental work. It weighs 0.5 pounds (0.2 kilograms).

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

Models PD, PCM, PC, PA

There are five variations of a basic two-handled, hand-powered, spring-operated jab planter.

Marila Industria E. Comercio Saszaki, Ltd.
Avenida Brazil, 232
Caixa Postal No. 196
Marila CEP 17.5000
Estado de Sao Paulo, Brazil

Hand-Operated Seed-Dressing Drum Plans

The object behind this drum was to build a seed-dressing device for village use, the design to be of fairly simple construction so that it could be made by local craftsmen.

The test drum used was an ordinary water tin of approximately 13 inches (330 millimeters) in diameter and 15 inches (382 millimeters) in height.

It was found that this drum had a capacity of 30 pounds (13.6 kilograms) of Chalimbana groundnuts, 35 pounds (15.9 kilograms) of soybeans or maize, and 38 pounds (17.2 kilograms) of fertilizer when filled correctly. In a durability test, a total of 1½ tons of fertilizer was mixed without signs of damage. The drum was also used for seed dressing of groundnuts and maize with satisfactory coverage performance and no apparent adverse effect on germination.

Intermediate Technology Publications, Ltd.*
9 King St.
London WC2E 8HN, England

THE HORN SEED SOWER

The simplest kind of broadcasting seeder, the Horn Seed Sower, consists of a reservoir which funnels seed into a long tube. The operator holds the tube, or horn, at the end closest to the reservoir, and with a skilled flex of the wrist, seed is flung out of the tube. It can be used to broadcast any seed to be grown in a solid stand and, in experienced hands, will result in a more even distribution of seed than would be achieved by hand alone.

SOURCES OF HORN SEED SOWERS

Horn Sower

This device sows primarily smooth grass or grain by swinging its horn back and forth. This sower spreads seed evenly from 30 to 40 feet at a rate determined by the adjustable feed gate in the base or tube joint and by rate of step. It comes with an 11-inch duck bag and an extension funnel attached to a tin distributing tube 22 inches long, 1¼ inches at the base and ¾ inch at the mouth. This sower has a capacity of ¼ bushel and a shipping weight of 1 pound, 8 ounces.

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

The Cyclone Seeder Co., Inc.
Box 68
Urbana, IN 46990

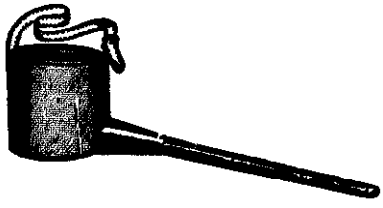
* Intermediate Technology publications can be ordered from International Scholarly Book Service, Inc., Box 555, Forest Grove, Oregon 97116.



Horn Sower with canvas bag.
Cumberland General Store

Horn Sower

This horn seed sower has a metal horn in three sections. It has an adjustable rate gauge and wire scatterer. The shoulder strap is also adjustable. It can be used for seeding grasses and small grains on any acreage. Its capacity is 1 peck.



Horn Sower
Cumberland General Store

Belknap, Inc.
P.O. Box 28
Louisville, KY 40201

Cumberland Country Store
Rt. 3, Box 479
Crossville, TN 38555

Glen-Bel's Country Store
Rt. 5, Box 390
Crossville, TN 38555

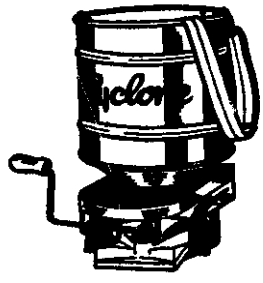
THE HAND-CRANKED BROADCAST SEEDER

A further refinement of the horn, the broadcast seeder hangs by a strap over the shoulder. Seed in the canvas bag or metal hopper flows through an adjustable hole in the bottom onto a distributing fan which is powered by a hand crank. The fan spreads the seed evenly over the ground. Adjustments let you alter your seeding rate to suit the crop. But remember that the speed with which you walk and turn the crank will also vary the seeding rate considerably. You have to learn to walk and crank uniformly and then match the seeder's adjustments to your motions. Cyclone and Universal are two popular brand names available from most hardware stores and country catalogs. Models are light- or heavy-duty, the former for sowing seed only, the latter for spreading fertilizer and lime. Don't try to spread fertilizer with the lighter models, though. Much larger broadcasters pulled behind a tractor and powered by a power take-off shaft are capable of extensive broadcast-planting coverage.

SOURCES OF HAND-CRANKED BROADCAST SEEDERS

Cyclone

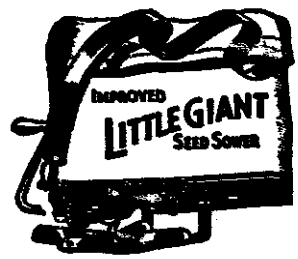
This is a triple-gear, adjustable sower with a self-feeding, oscillating feed plate. Equipped with a wide shoulder strap, an 18- by 6½-inch hardwood base, and spring stop, it is 10½ inches in diameter and weighs 5 pounds. It broadcasts all kinds of seed and is readily available through mail-order catalogs and hardware stores.



Cyclone
Cumberland General Store

Little Giant

This is a seeder with a double-feed flow to sow any kind of seed to be broadcast. It has an automatic feed flow which can be adjusted for any amount of seed per acre. Features include a wide shoulder strap, a 7- by 14½-inch hardwood base, a four-section distributing wheel 10½ inches in diameter, and a self-agitating feed plate. The seeder has a capacity of ½ bushel and is readily available through mail-order catalogs and hardware stores.



Little Giant
Cumberland General Store

For more information on either of the above seeders, write:
The Cyclone Seeder Co., Inc.
Box 68
Urbana, IN 46990

Collapsible Hand Spreader

A rotary agitator whirls material out to cover up to a 15-foot-wide swath depending on the density and particle size of the material being spread. It comes with an adjustable spreading rate gauge, spring load, trigger action on-off switch, die-cast metal gears, and measures 10½ inches high with a 9-inch diameter.

Other Hand-Cranked Broadcast Seeder Models

Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

E. C. Geiger
Rt. 63, Box 285
Harleysville, PA 19438

A. M. Leonard & Son, Inc.
P.O. Box 816
Piqua, OH 45356

Mother's General Store
Box 506
Flat Rock, NC 28731

Sears, Roebuck & Co.
Farm and Ranch Catalog

Hand-Pushed Broadcast Seeder

Cyclone also has a hand-pushed, broadcast seeder-spreader which is popularly used for spreading fertilizer. It is accurate in ounces or pounds per 1,000 square feet. A tapered-edge spreader eliminates skips and double overlaps. It comes equipped with micro dial settings for light, medium, or heavy applications, 8-inch wheels, T-bar handle, and a galvanized steel hopper. This seeder is easy to find in any hardware store or country catalog.

Casoron Spreader

The Geiger Casoron is a rigid, rust-resistant unit weighing 8 pounds. The Casoron spreader can spread or seed at a rate of from 50 to 500 pounds per acre. The flat base keeps the unit from tipping while filling. An adjustable control varies the swath width from 3 to 12 feet. The unit comes with a wide shoulder strap and a lubricated gearbox, sealed for protection.

E. C. Geiger
Rt. 63, Box 285
Harleysville, PA 19438

Hand-Pushed Row Seeders

Small row planters mount the seed box on one or more wheels which not only carry the seed box but activate a disc or plate, as it is called, in the bottom of the seed hopper. As the plate moves around, it allows the seeds to fall through the planting tube into the soil at regular, uniform spacings. In the simplest type of row seeder available, for example, the Plant-Rite and Dial-A-Seed seeders, the wheel *is* the planting disc. The smallest two-wheel seeder with changeable discs for different planting

intervals is the light Esmay seeder, which is regularly advertised and sold through catalogs and garden stores. A little larger and heavier, with a larger choice of planting depths and plates, are the Lambert, the Planet Junior, and one from Danville Manufacturing Co., Danville, IN 46122 (sold by Sears). There are probably others.

Lambert Corp.
519 Hunter Ave.
Dayton, OH 45404

Planet Junior Division
Piper Industries
P.O. Box 1188, Freeport Center
Clearfield, VT 84106

SOURCES OF HAND-PUSHED ROW SEEDERS

One-Wheel Seeders

With this unit, the wheel is the planting disc. It is sometimes called a Dial-A-Seed planter.

Countryside Catalog
Rt. 1, Box 239
Waterloo, WI 53594

Mother's General Store
Box 506
Flat Rock, NC 28731

Sears, Roebuck & Co.
Farm and Ranch Catalog

Wolf Tools for Lawn & Garden, Ltd.
Ross-on-Wye
Herefordshire HR9 5NE, U.K.

Two-Wheel Seeders

The lightweight version of two-wheel—one front, one rear—push seeders opens soil, spaces and covers seed, packs soil, and marks the next row in one operation. This unit usually comes equipped with six seed plates and an adjustable ground opener and row maker.

Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204

Countryside Catalog
Rt. 1, Box 239
Waterloo, WI 53594

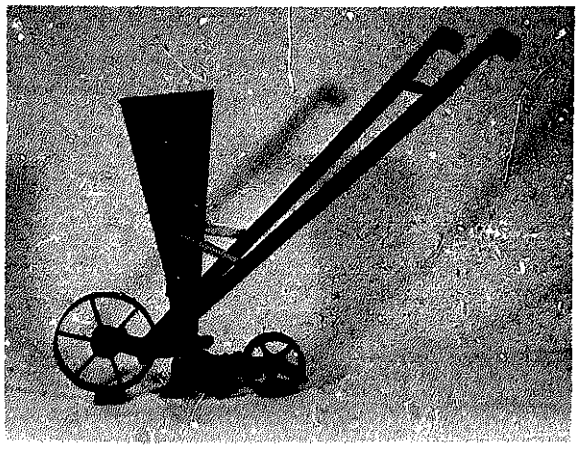
Esmay Products, Inc.
P.O. Box 547, Maple St.
Bristol, IN 46507

Farm & Fleet
1600 E. Lincoln Hwy.
DeKalb, IL 60115

Montgomery Ward
1000 S. Monroe St.
Baltimore, MD 21232

Sears, Roebuck & Co.
Farm and Ranch Catalog

American Spring & Pressing Works Pvt., Ltd.
P.O. Box 7602
Malad, Bombay 400 064, India



Before the development of a seed-metering device, this funnel seeder made hand seeding easier. One person would push as another rhythmically tossed seeds into the funnel.
Agriculture Canada

Heavyweight units are available from:

J. Gibbs, Ltd.
Stanwell Rd., Bedfont, Feltham
Middlesex, TW14 8ND, U.K.

Richmond Gibson, Ltd.
Salisbury Rd., Downton Salisbury
Wiltshire, U.K.

Lambert Corp.
519 Hunter Ave.
Dayton, OH 45404

Planet Junior Division
Piper Industries
P.O. Box 1188, Freeport Center
Clearfield, VT 84106

Polar-Werke, Engel & Sieper
Postfach 14 02 24/25
5630 Remschied 14, Germany

Project Equipment, Ltd.
Industrial Estate, Rednal Airfield
West Felton, Oswestry
Salop SY11 4HS, U.K.

Russel's (Kirbymoorside), Ltd.
The Works Kirbymoorside, Ltd.
York YO6 6DJ, U.K.

Sears, Roebuck & Co.
Farm and Ranch Catalog

Stanhay (Ashford), Ltd.
Ashford
Kent TN23 1PB, U.K.

Tanzania Agricultural Machinery Testing Unit
P.O. Box 1389
Arusha, Tanzania

A. J. Troster Landmaschinenfabrik
6308 Butzbach, Oberhess
Postfach 240, West Germany

Seeder Attachment

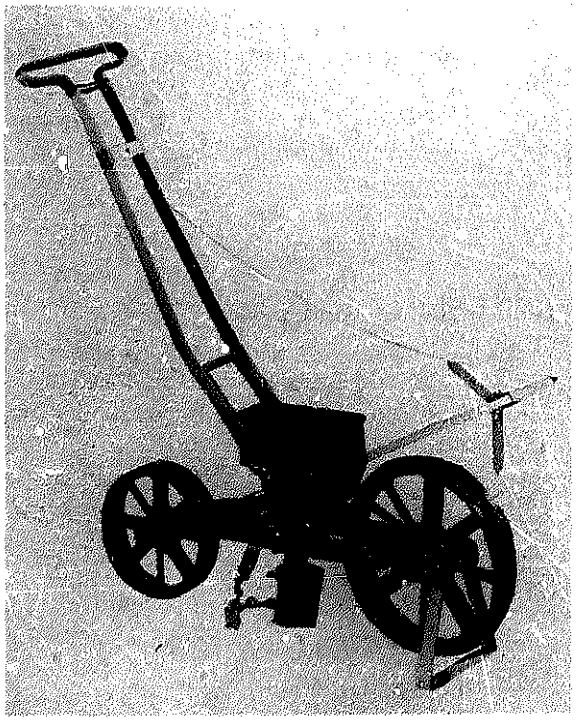
Offering versatility to the high-wheel cultivator, a seeder attachment opens the furrow, drops and spaces seeds, covers the furrow, and marks the next row. Six interchangeable seed plates make the unit able to handle seeds of all sizes.

Countryside Catalog
Rt. 1, Box 239
Waterloo, WI 53594

Montgomery Ward
1000 S. Monroe St.
Baltimore, MD 21232

Precision Garden Seeder

Constructed of corrosion-resistant materials, this push seeder comes with six seed plates for seed sizes ranging from radish seeds to corn and bean seeds.



Earthway Precision Garden Seeder
Esmay Products, Inc.

Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204

Countryside Catalog
Rt. 1, Box 239
Waterloo, WI 53594

Esmay Products, Inc.
Dept. 70GP2
Bristol, IN 46507

Montgomery Ward
1000 S. Monroe St.
Baltimore, MD 21232

Sears, Roebuck & Co.
Farm and Ranch Catalog

Professional-Type Seeder-Fertilizer

This seeder has a heavy-duty construction for large areas. It seeds and fertilizes in one operation. A choice of seven different-sized discs plus two sprockets offers over 20 spacing and depth combinations. The seeder opens the furrow, plants, covers, fertilizes on both sides of the seed, and marks the next row. It holds 1 quart of seed and 15 pounds of fertilizer, and has a shipping weight of 80 pounds.

Sears, Roebuck & Co.
Farm and Ranch Catalog

Golden Harvest Garden Seeder

This seeder opens the soil, plants and spaces seeds, covers and firms the soil, and marks the next row in one operation. It comes with six seed plates that will handle most seeds and has rear-wheel drive. The Seeder Attachment can be ordered to fit the high-wheel cultivator with a 24-inch wheel and a slot attachment foot, or as a separate implement. The seeder weighs 12 pounds, the attachment alone, 11 pounds.

Farm & Fleet
1600 E. Lincoln Hwy.
DeKalb, IL 60115

Mother's General Store
Box 506
Flat Rock, NC 28731

Garden Seeder

This Garden Seeder opens the soil, spaces, plants, covers seeds, and marks the next row all in one pass. A drag chain covers the seeds ahead of the rear wheel which then packs the soil. There are six plates for versatility, and a kickstand holds the seeder upright for filling the hopper. It has a shipping weight of 11 pounds.

Sears, Roebuck & Co.
Farm and Ranch Catalog

Planet Junior Number 4 Seeder

This seeder is available with or without cultivating attachments. With the attachments, it combines six tools in one:

1. an accurate hill-dropping seeder,
2. a rapid, continuous row seeder,
3. a light-running, single-wheel hoe,
4. a sturdy, single-wheel cultivator,
5. a furrower, and
6. a hand plow.

Shipping weight: 50 pounds.

Planet Junior Number 300A Seeder 7309X

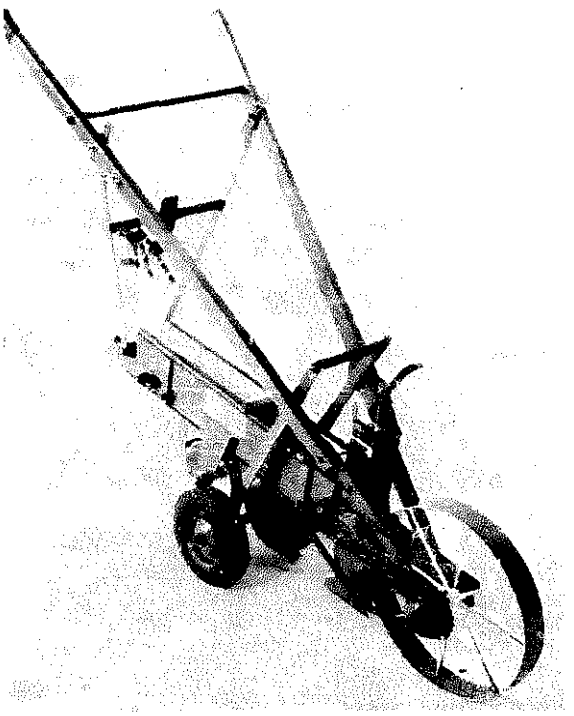
This seeder is equipped with three interchangeable plates with a total of 39 holes giving ample adjustment for any variety of seed. It includes a K712 opening plow. Shipping weight: 55 pounds each.

Planet Junior Division
Piper Industries
P.O. Box 1188, Freeport Center
Clearfield, VT 84106

Almaco V-Belt Planter and Applicator

The V-belt planter is available as either a hand- or power-driven unit. It is manufactured for experimental agronomic work at universities and research stations. Features include a planter shoe depth adjustment, a 14-inch, wide-faced drive wheel, six interchangeable sprockets, roller chain drives, V-belt tension adjustment, V-type covering wheel, rubber-tired running gear, and adjustable handles. It is designed for use in planting test plots and in applying fertilizers, insecticides, and granular materials. Two models are available.

Allan Machine Co.
P.O. Box 112
Ames, IA 50010



ALMACO Endless V-Belt Planter-Applicator
Allan Machine Co.

English Seeders

Two types of seeder are available from this company, and each may be pushed by hand or mounted on a Unibar animal-drawn tool bar. The reciprocating slide-action seeder was designed mainly as a precision seeder for use with hybrid maize, but can also handle groundnuts and beans using the standard maize slide. The seeder drops two or three seeds at 45-centimeter spacing with fertilizer alongside. Slides with smaller holes are available to enable sorghum, millet, and delinted cotton to be sown. A simple reciprocating action, combined with positive ejection of the seed (by slide-actuated springs), ensures trouble-free operation. The use of graded seed is preferable. Seeds and fertilizer are kept separate throughout, so that burning of the seed does not occur.

The roller-seeder can be supplied as a two-wheeled, single-row machine for hand propulsion or ridge planting with an animal-drawn tool bar. Multirow tool-bar-mounted versions can also be supplied. The seed rollers can be drilled to suit the customers' requirements, allowing any spacing along the row up to a maximum of 1.65 meters. Seed ejection from the rollers is positive.

Project Equipment, Ltd.
Industrial Estate, Rednal Airfield
West Felton, Oswestry
Salop SY11 4HS, U.K.

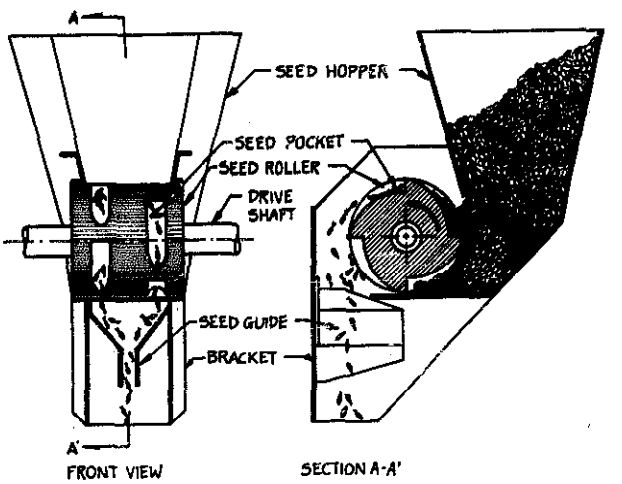
Hand-Operated Sowing Machine

Union Tractor Workshop
8–B, Phase II
Mayapuri Industrial Area
New Delhi 110 027, India

IRRI Multihopper Seeder

This unit was designed by the International Rice Research Institute in the Philippines for sowing pregerminated rice. It can sow 50 kilograms of pregerminated seed per hectare in 5 to 7 hours. Pulled by one man, the single central ground wheel drives the metering tools. Row spacing is 25 centimeters. This seeder requires:

1. pregerminated seed,
2. good water control at planting time, and
3. good land preparation.



IRRI Multihopper Seeder

D. H. Farm Implements
Km. 1, National Hwy.
Roxas City, Philippines

International Rice Research Institute
P.O. Box 933
Manila, Philippines

Kalayaan Engineering Co., Inc.
4255 Emilia St., Makati
P.O. Box 655 MCC
Rizal, Philippines

Quinzy-Pacific
Pasong Tamo, Makati
Rizal, Philippines

Aspee APS-61 Seeder

This hand-pushed seeder can sow all types of seeds in thin lines by metering them through holes in a plate. It is suitable for light soils and incorporates a furrow opener and seed coverer. Weight: 15 kilograms.

Aspee APS-53 Hand Hill and Drill Seeder

Suitable for hill and line drilling of seeds in soft or dry soils, this seeder plants practically all seeds, big or small, in hill spacings of 10, 15, 20, 30, or 60 centimeters. It opens the furrow, drops the seed to the proper depth, covers it evenly, firms the soil over the seed, and marks out the next row in one operation.

A lever instantly shuts off the flow of seeds when handles are raised for drawing back or turning at the end of a row. Weight: 12 kilograms.

Aspee APS-54 Seed Drill and Wheel Hoe

This dual-purpose implement cuts the soil, drills seeds, covers them with soil, and packs them into the soil. The line-sowing mechanism drops seeds at the required spacing. It is suitable for small seeds such as wheat, rice, jute, linseed, mustard, and others. Weight: 15 kilograms.

All three above seeders are available from:
American Spring & Pressing Works Pvt., Ltd.
P.O. Box 7602
Malad, Bombay 400 064, India

Cottonseed Planter

This implement was especially developed for planting nondelinted cottonseed. Spacing between plant stands can be 17, 20, or 31 centimeters and six or seven seeds are planted at each stand. Alternative seed plates allow the machine to be used for planting other crops such as groundnuts, millet, maize, and sorghum. Weight: 39 kilograms.

E.B.R.A.
28, rue du Maine, B.P. 84
49009 Angers, France

Direct Seeder

A two-row hand-drawn machine for upland rice culture, with different feed rollers, it can be used for planting other seeds such as wheat, barley, maize, sorghum, and millet. Capacity of each hopper is 2.2 liters. Spacing between rows is adjustable from 150 to 360 millimeters.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

The Bean Drill

This single unit, thin-line drill is capable of handling all sizes of seeds, from the smallest up to peas and small beans. It sows at a predetermined depth with the row covered. The drill coulter is adjustable for depth, and the metal agitator ensures positive seed flow. Standard specifications include shut-off control, adjustable marker, and four seed plates giving 46 holes from 2.5 to 25 millimeters in diameter.

J. Gibbs, Ltd.
Stanwell Road, Bedfont, Feltham
Middlesex TW14 8ND, U.K.

Exel Hand Seeder

This push-type seeder unit is designed for drilling most types of vegetable seed on the flat. It is suitable for small market gardens where the seedbed has been well prepared. Twin rubber-tired wheels drive the mechanism, which consists of an aluminum cell wheel suited to the crop being sown. The hopper has a 2-pint (1-liter) capacity, and a simple seed coverer is provided.

Russel's (Kirbymoorside), Ltd.
The Works Kirbymoorside, Ltd.
York YO6 6DJ, U.K.

Hand-Pushed Seed Drill

This is a precision seeder in which seeds are metered through a perforated belt, resulting in minimal seed damage. Seeds which are approximately spherical (or pelleted into spherical pellets) can be drilled singly. Seeds such as lettuce or carrot can be distributed at an average of two seeds from each belt perforation. Group spacings can be arranged: two or three seeds 25 or 50 millimeters apart, followed by a gap before the next group of seeds. Double and treble line coulters are available to sow two lines of seeds 50 millimeters apart, three lines 25 millimeters apart, or th[illegible]38 millimeters apart. This device is suita[illegible] nearly every type of seed up to the size of beans, peas, or maize. Two or more seeder units can be mounted on an animal-drawn tool bar.

Stanhay (Ashford), Ltd.
Ashford
Kent TN23 1PB, U.K.

Hand Seeder

A.J. Troster Landmaschinenfabrik
6308 Butzbach, Oberhess
Postfach 240, West Germany

I.A.R.I. Single-Row Seed-Cum-Fertilizer Drill

To operate this seeder designed by the Indian Agricultural Research Institute, one man pulls a rope attached at the front of the implement, while a second man steers.

Union Tractor Workshop
8–B, Phase II
Mayapuri Industrial Area
New Delhi 110 027, India

Semoir A Main

This hill drop seeder with 5-liter hopper capacity is driven by three sprocket wheels. Depth is adjustable on the shoe and the action of the press wheel is completed by two covering knives. Two models are available, one with row marker, weighing 25 kilograms, and one without a marker weighing 21 kilograms. Both are provided with 75 different seed plates.

E.B.R.A.
28, rue du Maine, B.P. 84
49009 Angers, France

Polar-Werke, Engles & Sieper
Postfach 14 02 24/25
5630 Remschied 14, Germany

Tanzania Agricultural Machinery Testing Unit
P.O. Box 1389
Arusha, Tanzania

Mini Nibex Planter

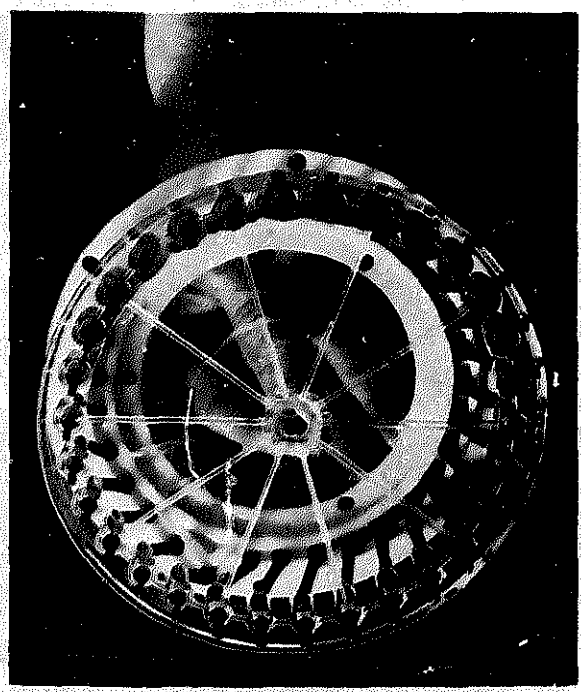
The Mini Nibex hand planter is for growers with up to 10 acres and will sow up to 2 acres in a day. The Nibex cup system includes 25 types of cups for different seeds—both natural and pelleted. This wide range makes it possible to be able to choose the most suitable



Mini Nibex Hand Planter
Nibe-Verken AB

cup for the desired drilling method. The seeding rate can be varied from 4 to almost 2,000 seeds per running yard—either thin-line or hand-drilled in widths of 2, 2.5, or 4 inches (50, 65, or 105 millimeters). The cup system is largely unaffected by variations in seed size. To reduce the amount of seed required when sowing small and expensive seeds, a regulator-economizer insert is available for use in the seed-housing unit.

When a suitable drilling depth has been established and the seed distribution mechanism has been set for the desired number of seeds per yard, the Mini Nibex is ready for sowing. The coulter gives the furrow the correct depth, the cups distribute the seed in the desired way, the presswheel beds them down in the moist earth, and the coverers enclose them with loose soil.



Thirty-one seed-distributing cups are housed in this chamber, which is interchangeable to accommodate different seed sizes.
Nibe-Verken AB

Cups are easily switched for fast changes between seeds. The relationship between cup type, number of cup feeds per yard, and number of seeds sown per yard can be found in the detailed sowing instructions.

The seeder unit is mounted between two supporting wheels which are 4 by 16 inches, or 105 by 400 millimeters in diameter, and the bearing surfaces are perforated to prevent packing and crusting of the soil. Drive is from the front wheel via two chain transmissions. The changing sprockets offer 59 selections, from 3.5 to 86 cup feeds per yard. Drilling depth is progressively adjustable by means of two handwheels. Changeover is performed without tools.

Nibe-Verken AB
S–285 00 Markaryd
Sweden

CONE SEEDERS

Cone seeders have been an important development in equipment for research or experimental agriculture. Seed poured into a small funnel at the top of the cone is distributed evenly at the base when the funnel is lifted. The cone is geared to rotate one full turn in the plot length with a scraper deflecting the seed to the furrow opener. The cone base is roughened to prevent the seed from rolling.

SOURCES OF CONE SEEDERS

Craftsman Cone Seeders

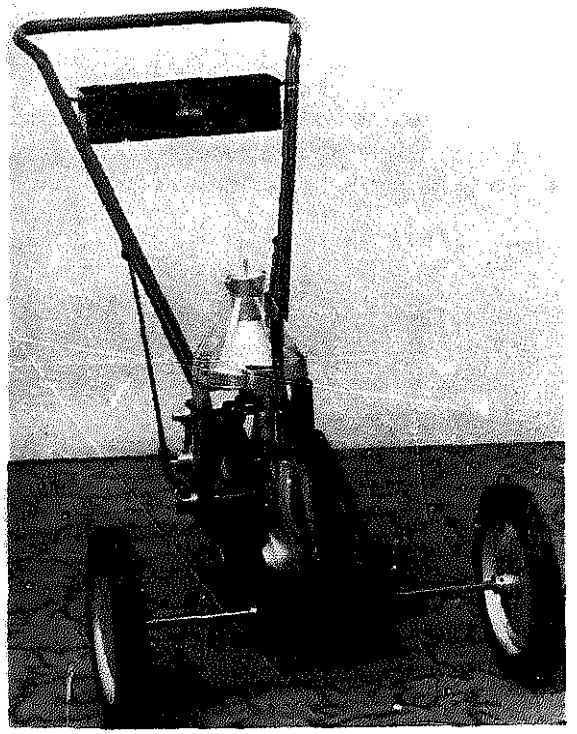
Cones are available as single units or mounted in groups for installation on custom-built drills. They can be supplied with a 7- or 14-inch base diameter and with either knurled or plain base plates.

Craftsman also manufacturers a hand-pushed, single-row seeder with single- or double-metering cones. It has a three-wheel chassis with 12-inch, double-disc openers. Sprockets are available to adjust for row length. The two-cone model is used for simultaneous fertilizer or insecticide treatments during seeding.

Craftsman Machine Co.
61 Heaton
Winnipeg 2, Manitoba, Canada

Chain's Cone Planter

A planter manufactured by Chain Machine Company has four cone dispensers mounted on a 12 h.p. compact tractor. The cones are driven



Craftsman cone seeder for research plot work.
Craftsman Machine Co.

through a multiselection chain and sprocket drive from the rear wheel with selections for plot lengths from 4½ to 30 feet. The double-disc openers are hydraulically controlled and can be equipped with firming wheels and drag coverers. Two seats are provided for operators to load the cones.

> NOTE: This planter is referred to as a precision planter in the manufacturer's literature. This refers to the precision manufacture and not to precision planting, which requires a seed-cell planter and a short, controlled seed drop.

Chain Machine Co.
112 N. Kansas
Haven, KS 67543

The Swanson Planter

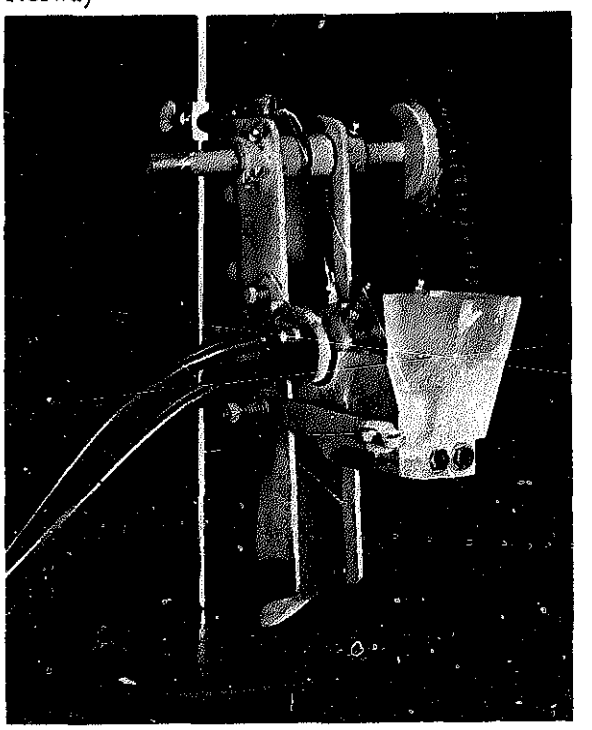
The Swanson plot planter, developed for small test plots for such seeds as soybean, sorghum and kenaf, uses a cone arrangement similar to the Craftsman cone. Sprockets are available for rows 3 to 32 feet long.

Swanson Machine Co.
20-26 E. Columbia Ave.
Champaign, IL 61820

A Norwegian Cone Seeder

The Oyjord plot drill has a single cone-type dispenser feeding a spinning divider which divides the sample into 2, 4, 6, 8, or 10 openings to correspond with the number of row openers used. The row length can be adjusted to any size between 13 and 49 feet. The drill is available with a three-point hitch or as a self-propelled model with a 4 h.p. engine. A planting rate of 60 to 100 plots per hour is claimed. Equipment for continuous drilling and press-wheels are optional extras. The cone dispenser differs from the Craftsman type in that the seed is guided around a fixed base by wipers and drops from a hole in the base.

Jens A Schou Mek Versksted
Drobak
Norway



Suction-Spaced Seeder Agriculture Canada

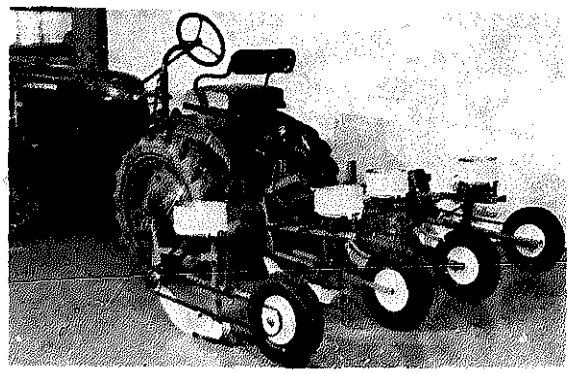
Suction-Spaced Seeder

This plant seeder has been the inspiration behind many new types of planters. It was originally developed by Mr. L.G.I. Copp of the Crop Research Division, Department of Scientific Research, in Christchurch, New Zealand. It is a one-row planting unit, and mounts on a two-wheel tractor. Seed is picked up by vacuum through hypodermic needles on a revolving drum with a small vacuum pump.

W.A. Habgood, Ltd.
Lincoln, New Zealand

Soybean Planter

Originally developed by the Engineering Research Service of Agriculture Canada, this soybean planter for population studies is now available commercially in an improved form, making it suitable for repetition planting of large numbers of samples at different spacings. The original models used seed hopper bottoms mounted on a lightweight frame for adjustable row widths. Spacing within the rows was by sprocket and seed plate selection. Seed accuracy has been improved by using brush cutoffs and a smooth drop tube. The planter mounts on a four-wheel tractor.

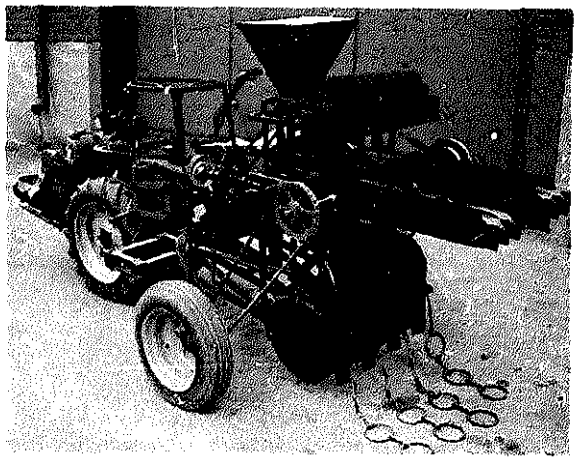


Soybean Planter
Agriculture Canada

Mear Supply
327 Townline
Carleton Place, Ontario, Canada

Four-Row Plot Seeder

Seed is fed to the openers of this self-propelled seeder by either a V-trough belt or a fluted dispenser and a four-way spinning divider. It is designed for the exacting requirements of research plot experiments. Fertilizer may also be applied through a belt attachment. The four-row seeder pictured here is now obsolete because it was made to attach to a Bolens Ridemaster tractor, which is no longer being produced. However, models by other manufacturers are available. Plans are available from the Engineering Research Service, Agriculture Canada, Ottawa, Ontario K1A 0C6 Canada, and similar seeders are commercially available.



Four-row Plot Seeder
Agriculture Canada

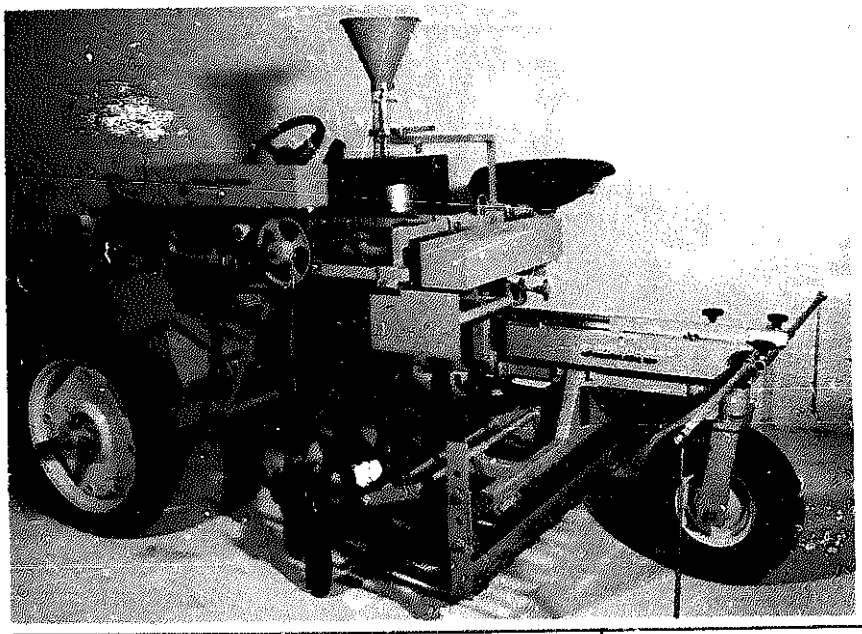
Fabro, Ltd.
Swift Current
Saskatchewan, Canada

Mear Supply
327 Townline
Carleton Place, Ontario, Canada

Two Plot Drills

The first of these is a three-row planter employing two operators, one pulling and the other pushing, and using a seed cup to dispense seed to three row openers. The delivery rate is adjusted by a plate at the bottom of the cup. The cup is hinged to permit dumping of leftover seed.

Bill's Welding
South Grand St.
Pullman, WA 99163



Walter and Wintersteiger Plot Drill
Walter and Wintersteiger

The Walter and Wintersteiger plot drill is a three-wheeled, self-propelled model available with either a full-width or individual hopper seed box. Metering is done by a fluted wheel. The seed boxes have a provision for dumping unused seed. The machine can be purchased with three to eight row openers and with a two- or three-speed gearbox. Cultivating and spraying attachments are available.

F. Walter & H. Wintersteiger
4910 Ried im Innkreis
Frasch augasse 19, Postfach 124
Dimmelstrasse, Austria

Toothed-Wheel Seeders

Some European seed drills are suited to planting larger plots in that they are mounted on a three-point hitch and have a catch pan to collect seed when regulating the dispensers or when emptying the seed box through an unloading valve at each run. Individual runs can be shut off as desired, or hopper inserts can be used for seed separation in the box. The most common dispenser is a toothed-wheel metering device driven by a gearbox with up to 81 selections.

Manufactured by: Fiona, Denmark
Sold by: J.F. Farm Machinery
Exeter, Ontario

Manufactured by: P. Nordsten, A/S
Hillroed, Denmark
Sold by: G. White & Sons
London, Ontario

Manufactured by:
A.J. Troster Landmaschinenfabrik
6308 Butsbach, Oberhess
Postfach 240, West Germany

Plantox Drill

The Plantox drill is a machine mounted on a three-point hitch suitable for horticultural and forestry plantings. The five-row distributor is driven from the tractor PTO. All types of seeds can be planted in rows or wide beds.

Zijlstra en Bohuis NU
Beneden Weerdiep 105
Veedam, Holland

Finlay Plot Seeder

The Finlay plot seeder is a sophisticated semiautomatic machine for planting large numbers of plots per day. It uses cartridge loading and a false-bottom seed dispenser, and is available with one to nine row openers.

B. Forrest, Metal Patterns, Ltd.
749 Port Rd.
Woodsville, S. Australia

Svenska Plot Seeder

A plot seeder for sugar beet experiments, this unit meters a premeasured quantity of seed to a plot row and is available as one-row units.

Svenska Sockerfabriks Aktiebolaget
Betmekaniseringsavdelningen
Kavlinge, Sweden

Habgood Vacuum Planter

A vacuum pickup planter suitable for precision planting of any type of seed is available for tool bar mounting. A source of vacuum is required to provide suction to hypodermic needles mounted on a revolving cylinder.

W.A. Habgood, Ltd.
Lincoln, New Zealand

Mat-OSU Planter

The Mat-OSU planter was developed at Oregon State University for fertilizer trials. Commercial planters were found unsuitable for the precise planting required, so a vacuum pickup wheel was developed. It has been found suitable for grass, legume, cereal, flower, and tree seeds without grading the seed. Row spacing is adjustable from 12 inches to 6 feet. Fertilizer metering is by Cole top delivery hoppers. Fertilizer can be placed accurately at varying positions in relation to the seed.

Mater Machine Works
520 S. 1st St., Box 410
Corvallis, OR 97330

MacKey Plot Drills

The MacKey plot drills use a dispenser consisting of a base plate with grooves corresponding to the number of openers, and a seed tray with a press plate which slides along the grooves to deliver seeds to the seed tubes. The tray is geared to traverse its length over the plot length.

The hand-pushed model has one to three openers spaced at 6-inch intervals and can be geared for rows 40 to 80 inches long. One hundred 5-foot rows can be planted per hour. The power model has five openers and can be geared for 10- to 20-foot plots. Its capacity is 100 10-foot plots per hour.

Maskinfirma Tuland
P.O. Box 107
Landskrona, Sweden

A Seeder for Cereals

The N.I.A.E. spaced plant seeder was developed to replace hand dibbling of cereal grains for lattice-planted plots. The planter is cam operated to plant seeds 2 inches apart on a 6-inch row spacing. Holes are made by a series of dibblers, each consisting of a tube into which a plunger is inserted just before the tube enters the soil. The plungers are then raised and the seed is released from a preloaded, plastic seed magazine. A sowing rate of 500 rows per hour can be attained with a five-man crew. Twenty-three seeds are spaced in a 4-foot row. The planter is powered by a small engine with a 45:1 reduction box.

R.G. Garvie & Sons
2, Canal Rd.
Aberdeen, Scotland

SOURCES OF ANIMAL-DRAWN SEEDERS/PLANTERS

The Ferguson Planter

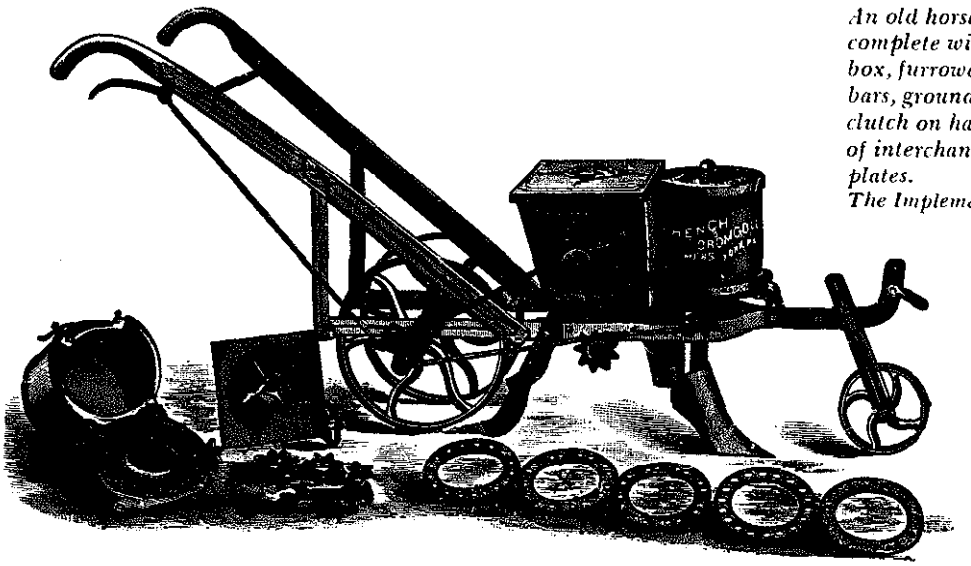
The Ferguson All-Purpose Planter is a one-row, team model planter with a duplex hopper and unique plate design. Shipping weight: 120 pounds.

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

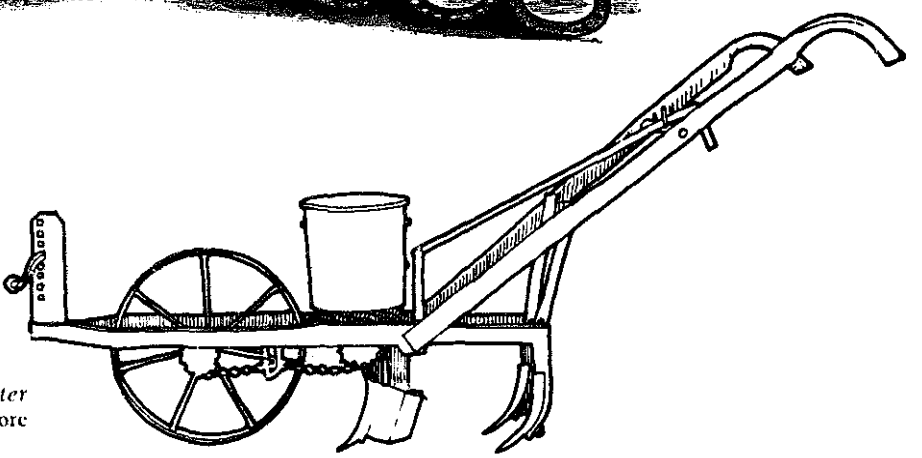
A Two-Row Planter from India

Sowing depth is adjustable on this all-steel-constructed, two-row unit. Row spacing is adjustable from 175 to 450 millimeters.

Rajasthan State Agro Industries Corp., Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006, Rajasthan, India



An old horse-drawn corn seeder complete with fertilizer box, seed box, furrower, soil-packing bars, ground-drive wheels, seeder clutch on handles, and a variety of interchangeable seed metering plates.
The Implement Age, 1894



Ferguson Planter
Cumberland General Store

Automatic Rabi Drills

Wooden-framed and all-steel models are available for sowing grain 20 centimeters between rows.

Automatic Kharif Drills

These are two-row drills for sowing seeds at wide spacings of 60 to 70 centimeters between rows. They are suitable for sowing maize, delinted cotton, and other seeds. Models with wooden frames or with all-steel construction are available.

Both the above types of drills are available from:
Danishmand & Co.
Karkhana Bazar
Lyallpur, Pakistan

Types ASD and RSD Seed and Fertilizer Drills

With working widths of 1.25 to 2.50 meters and row spacing adjustable from a minimum of 154 millimeters, this unit is fitted with a steerable front axle. Various types of furrow openers are available for different soil types. The fertilizer can be sown together with the seed or at the side of the seed rows, as required. This unit is available with either fluted roller seed metering or star wheel fertilizer metering.

A.J. Troster Landmaschinenfabrik
6308 Butzbach, Oberhess
Postfach 240, West Germany

Rice Seeder

This is a two-row seeder unit which can be fixed to the frame of the Occidental Hoe. The

large-capacity hopper feeds the seed into a furrow dug by the two rear hoe blades, which can be adjusted to give row widths of 12 to 16 inches (.30 to .40 meters). Total weight, including the hoe unit, is approximately 100 pounds (45 kilograms).

Siscoma
B.P. 3214
Dakar, Senegal

Safaim Pitman Drive Planter

The Safaim Pitman Drive Planter is designed for maize planting but can be supplied with special attachments for cotton. It comes fitted with a fertilizer attachment and weighs 64.5 kilograms (142 pounds).

Massey-Ferguson South Africa, Ltd.
Steel Rd., P.O. Box 677
Vereeniging 1930, South Africa

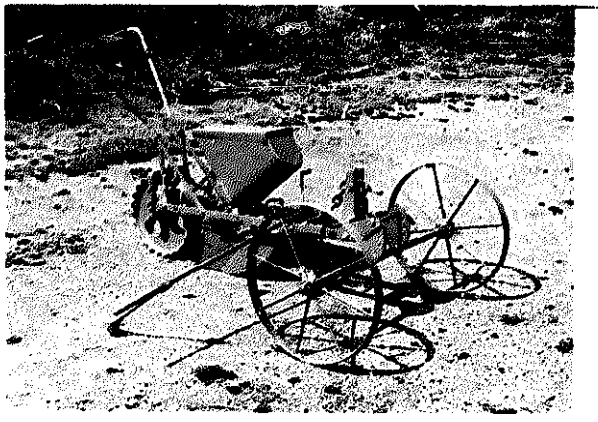


Seeding ridges with animal-drawn equipment.

Super-Eco Seeder

This is an all-steel seeder unit with two large wheels driving the mechanism. Different plates or distributors are available for sowing groundnuts, millet, sorghum, maize, rice, and several types of vegetables. The unit is fitted with two handles, a furrow opener, coverers, a presswheel, and a row guide for marking subsequent rows. The weight is approximately 82 pounds (37 kilograms), and the unit can be drawn by a single donkey or bullock.

Societe des Forges Tropicales
B.P. 706
Douala, Cameroun



E.B.R.A. Animal-Drawn Seeder

E.B.R.A. SU 201 Animal-Drawn Seeder

This animal-drawn seeder is designed for use on the ridge or on the flat. The hopper has a capacity of 8 liters and the two front wheels are adjustable. Drive is through a series of sprockets which can be altered to vary the spacing in the row. Seed depth is adjustable on the shoe, and the unit is fitted with a presswheel and covering knives. A wide range of seed

plates are available for planting the smallest to the very largest-sized seeds.

E.B.R.A.
28, rue du Maine, B.P. 84
49009 Angers, France

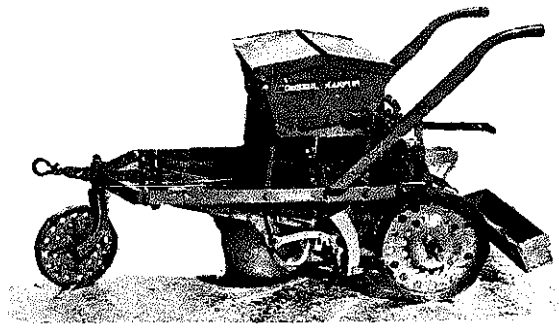
Seeder

Another animal-drawn seeder is made by:

Project Equipment, Ltd.
Industrial Estate, Rednal Airfield
West Felton, Oswestry
Salop SY11 4HS, U.K.

Automatic Seed-Cum-Fertilizer Drill

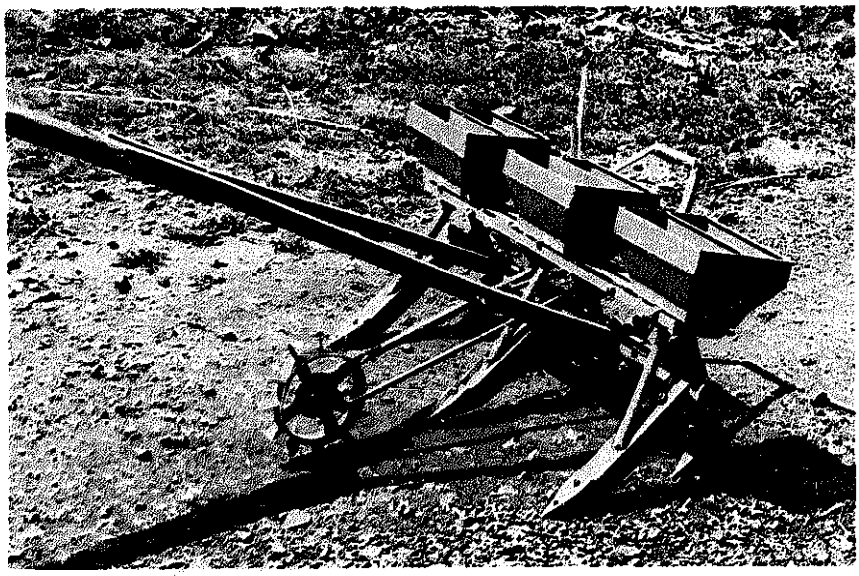
This drill is light in draft and is fitted with disc furrow openers. The row width is adjustable from 150 to 250 millimeters. A fluted roller feed mechanism is used. The three-row model weighs



Seed-Cum-Fertilizer Drill
Cossul & Co.

95 kilograms and the five-row model, 110 kilograms.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India



Maharashtra
Seed-Cum-Fertilizer Drill
Maharashtra Tokan Yantra

Seed-Cum-Fertilizer Drill

This three-row drill has reciprocating plate metering mechanisms operated by a bell crank system from the land wheel. Row spacing is adjustable from 228 to 456 millimeters. Individual hoppers for each row allow the machine to be used for mixed cropping.

International Mfg. Co. (Regd.)
Hospital Rd., Jagraon
Ludhiana, Punjab, India

Maharashtra Tokan Yantra
Market Yard, Karad
Dist. Stara, Maharashtra, India

The Rajasthan Automatic Seed-Cum-Fertilizer Drill

This is a three-row machine capable of drilling small grain seed and fertilizer in one operation at an adjustable sowing depth.

Rajasthan State Agro Industries Corp., Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006, Rajasthan, India

Sisag Softroll Seeder Unit

Developed by the British National Institute of Agricultural Engineering, it will handle a wide range of seeds without fear of crushing or bruising. A pair of resilient neoprene rollers at the base of the hopper meter the seed (or fertilizer); metering is altered by varying the speed of the rollers. The unit can be adapted to feed a number of coulters, and is shown mounted on the rear of a tool bar.

Sisag Equipment Maccles-Field, Ltd.
Shoresclough Works, Hulley Rd.
Macclesfield, Cheshire SK10 2LZ, U.K.



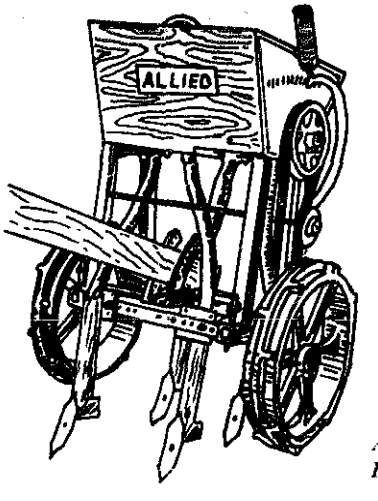
Sisag Softroll Seeder Unit

Tanzanian Animal-Drawn Seed Drill

Ubungo Farm Implements
P.O. Box 2669
Dar Es Salaam, Tanzania

Allied Seed-Cum-Fertilizer Drills

Both two- and three-row models are available for sowing wheat, barley, maize, groundnuts, and rice seeds. A V-belt ground drive from the wheel drives the unit; seed rate is adjusted by a single lever, and the seeding mechanism is automatically engaged or disengaged when the tines are lowered or raised. Large wheels provide a low draft.



Allied Seed-Cum-Fertilizer Drill

Allied Trading Co.
Railway Rd.
Ambala City 134 002, Haryana, India

Single-Row and Three-Row Rice Seeder Plans

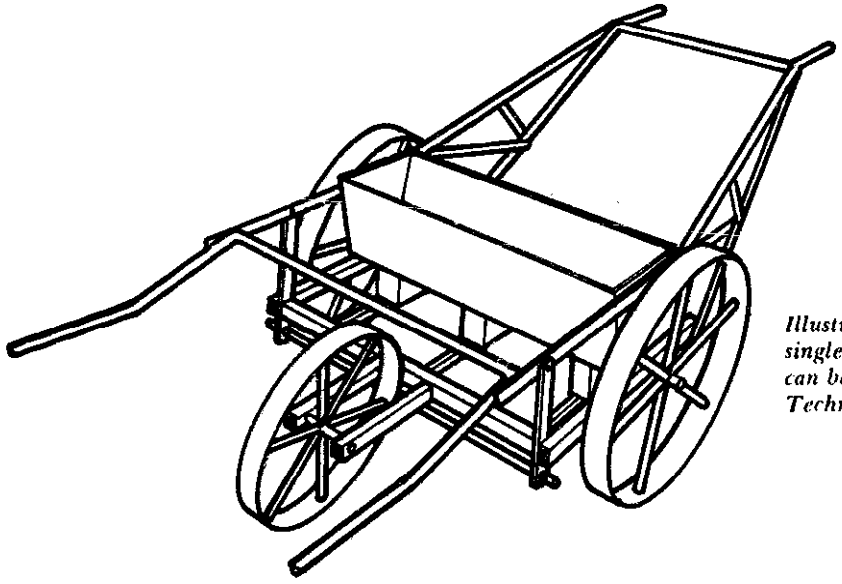
Plans for these seeders which originated in Zambia, are available from:

Intermediate Technology Publications, Ltd.
9 King St.
London WC2E 8HN, England

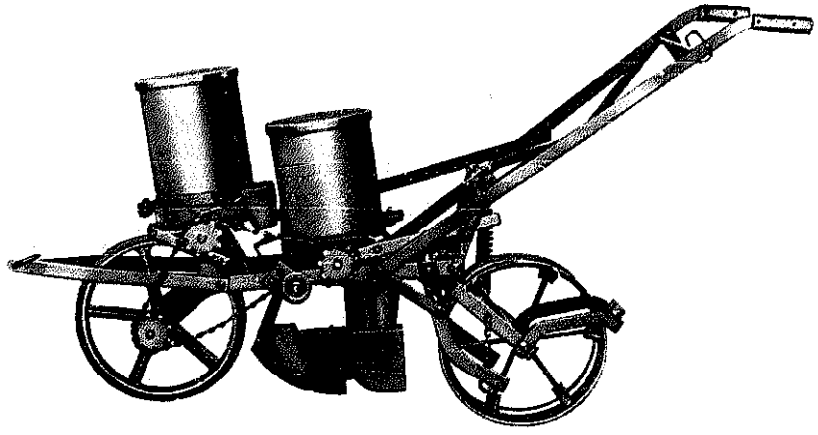
Jumil J-1 Planter

This planter, which also opens furrows and fertilizes, can be used on flat as well as mountainous terrain. It plants hard seeds such as corn and rice, soft seeds like peanut and castor bean, and cottonseed. Granulated, concentrated, or humid fertilizers can be used, or, if the soil is exceptionally fertile, the unit can be delivered without the fertilizer spreader.

Jumil
Justino de Morais, Irmaos S.A.
Rua Coriolano 380, Sao Paulo S.P., Brazil



Illustrated directions for constructing single-row and three row rice seeders can be obtained from Intermediate Technology Publications.



Jumil J-1
Jumil

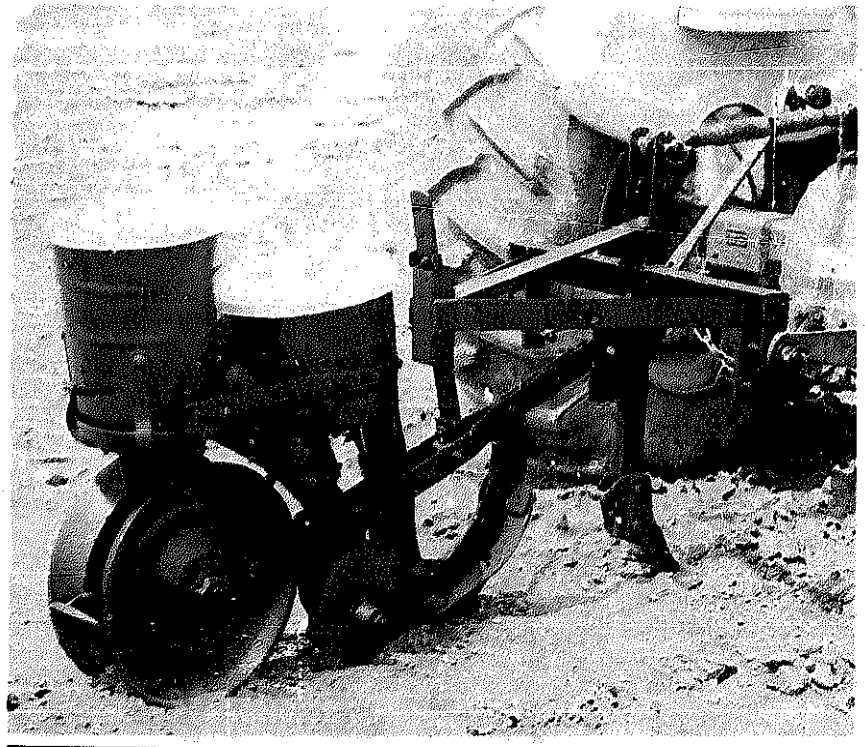
TRACTOR-DRAWN UNIT PLANTERS

Many of the units described as hand-operated are also available with hitches for drawing by tractor. Larger, heavier planters, like the Brinly-Hardy (Louisville, KY 40200) and the Cole (Charlotte, NC 28200) are designed for tractor use only. The Brinly is for tractors with horsepower from 8 to 18, and the Cole for

tractors on up to perhaps 15 to 25 horsepower. These seeders attach to three-point hitch arrangements or other hydraulic lift systems.

Larger and heavier commercial farm planters of great precision can now be purchased in single-row versions. The new planters, like those now available from all the large farm equipment companies like John Deere and International Harvester, are called unit planters. Each planting unit is powered by its own drive wheel, so many units can be used together. You will have to make your own hitch arrangement to attach one of these units to your tractor as it is not made for mounting on a tool bar. But the small commercial grower may find adapting a unit seeder well worth the effort, since these planters generally do a better job of planting than the smaller garden planters.

It may be practical, with the unit planters mentioned above, to go to a two-unit planter if you are row cropping more than four or five acres. The smaller Cole is a sort of unit planter, that is, two units can be put together quite easily. Old, obsolete, two-row planters originally designed for horses or smaller farm tractors also make fine tools for homesteaders with just a few acres to plant, but they are becoming scarce. Old four-row planters are now easier to find, but they are a little large for the typical homestead. However, you can modify one to a two-row model, or if you are mechanically equipped, you can take a single unit from a four-row or two-row planter and convert it to a single-row seeder. It means, on four-row models especially, converting the presswheel that presses the dirt on top of the planted seed, into a drive wheel to turn the planting plates. Older four- and six-row planters do not have a drive wheel for each unit.



Cole No. 12 Planter
Cole Mfg. Co.

SOURCES OF TRACTOR-DRAWN UNIT PLANTERS

Cole Number 12 Planter

Designed for the small farmer, the No. 12 is a garden planter with opening foot and three-point hitch for use with category 0 and 1 tractors. The planter simultaneously plants seed and side-dresses fertilizer. It has a single, inclined-plate seed hopper with a set of four seed plates for planting corn, large and small squash, small limas, okra, tomatoes, peas, and snap beans in hill or drill fashion. Other seed plates are avail-

able. A set of four distance gears for changing spacing is included. Fertilizer is placed beside the seed to prevent any fertilizer damage in germination. The galvanized, fertilizer hopper has a 40-pound capacity and a rate of application adjustable from 34 to 650 pounds. It will apply any dry fertilizer. An opening shank is included (sweep is not included).

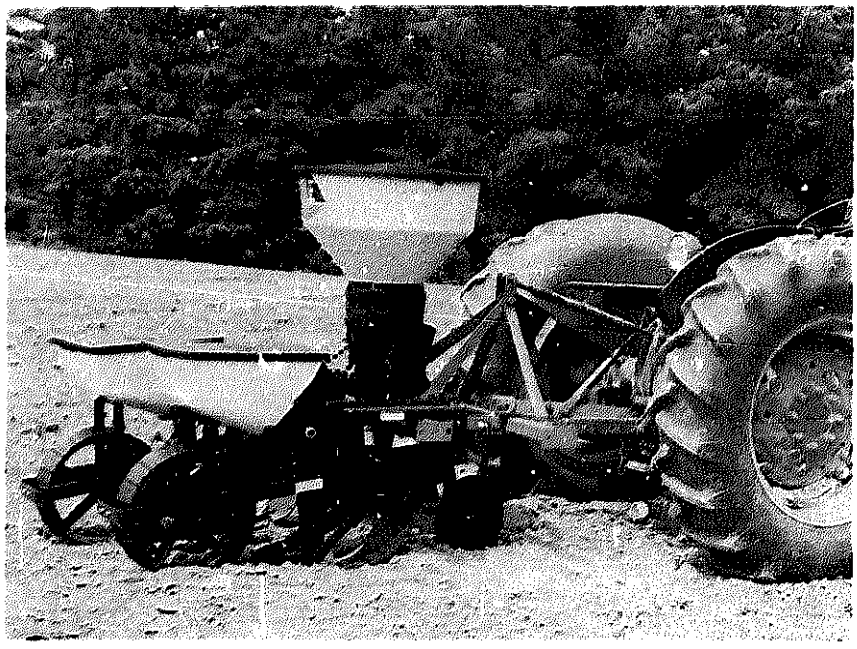
Cole also offers a variety of hitches to mount the No. 12 planter to almost any tractor. These include International Harvester Models Super A, 140, and Cub tractors, both with and without fast hitch. They also have hitches for tool bar applications and for mounting the planter to other cultivators. All units are available worldwide.



The INTEC two-wheel tractor with a Cole No. 12 Planter attached. Often, equipment has applications even its manufacturer hasn't thought of.
Dowding Tool Products, Inc.

Cole's 210 Series

A lift-type, 50-inch carrier with category 1 three-point hitch and front and rear tool bars allow the farmer to simultaneously plant and put out fertilizer. He has the option to use either one or two fertilizer hoppers, one of four planter chassis, and three seed hopper options. Fertilizer is placed by two disc-side placers and run by a ground-drive wheel. Seed spacing, seed depth, and seed plates may be changed without special tools. A wide variety of plates is available for all seed hoppers. Cole also offers many attachments to fit a farmer's needs, such as gauge wheels, spring shanks, furrow openers, bed levelers, cotton attachments, and depth gauge extensions. Granular chemical applicators are also offered for both herbicides and insecticides.



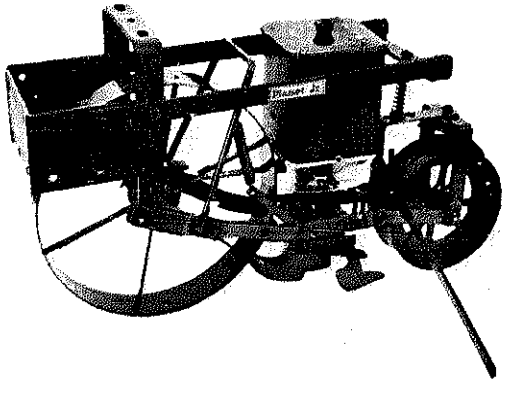
Cole Economy 210 Series
Cole Mfg. Co.

Cole Mfg. Co.
1318 Central Ave.
Charlotte, NC 28299

Planet Junior Number 9192X Unit Seeder

Inside its own individual mounting cradle, this seeder unit is spring-suspended. This permits each unit to follow the contour of the ground assuring uniform depth of planting. It is suspended so that down pressure or lifting action is accomplished by actuating the tractor lift device. Units may be mounted in multiple-row applications at minimum-row widths of 9 inches, and are ground driven. Shipping weight: 56 pounds.

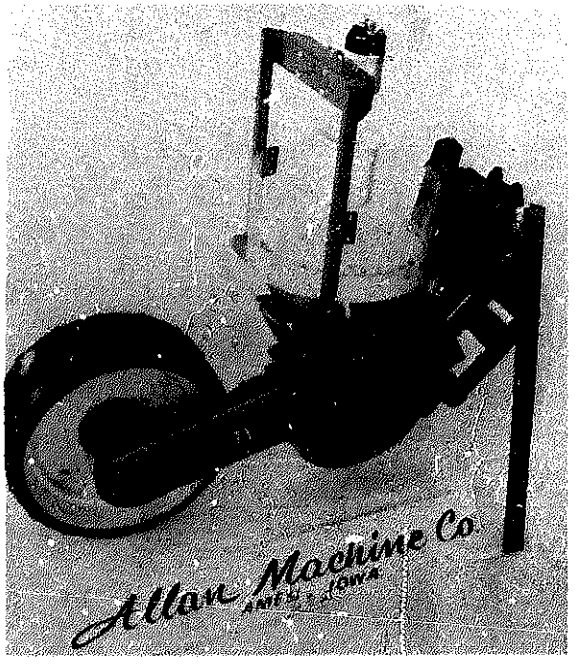
Planet Junior Division
Piper Industries
P.O. Box 1188, Freeport Center
Clearfield, VT 84106



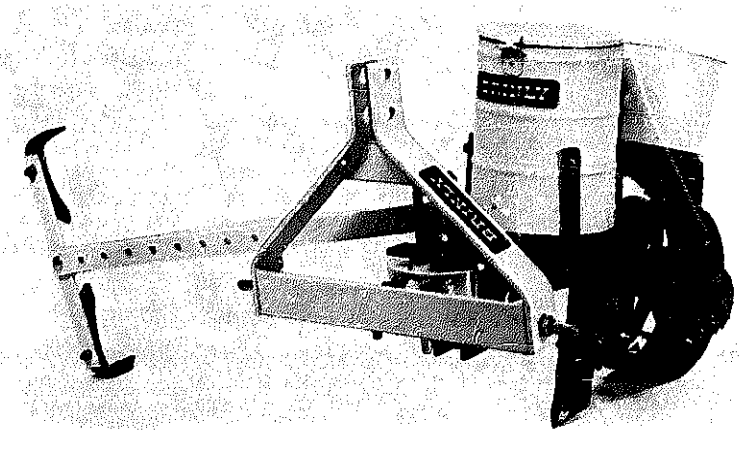
Planet Jr. No. 9192X Unit Seeder
Piper Industries

ALMACO Cone-Type Nursery Seeder

This machine was developed specifically for planting small plots of corn, sorghum, soybeans, cereals, and other grain crops. These are seeder units which fit into the seed hopper box of commercial row planters like John Deere and International Harvester for planting nursery rows and space planting a large variety of seeds. This model has a cast aluminum base, 12½ inches in diameter.



ALMACO Cone-Type Nursery Seeder
Allan Machine Co.



Brinly-Hardy vegetable planter with row marker and fertilizer hopper.
Brinly-Hardy Co.

Allan Machine Co.
P.O. Box 112
Ames, IA 50010

Model KK-305 Vegetable Planter

A ground-drive unit for use in prepared soil, it is capable of planting seed as small as radish and turnip, as well as corn, beans, and peas. It opens the furrow and then drops and covers the seed at the desired spacing. It features a large-capacity seed hopper, a new float plate that allows the planter to follow ground contours, a new shovel-type opening foot, a new, larger, concave drive wheel which improves traction, reduces the possibility of skidding, and improves seed coverage. It is equipped with five quick-change seed plates, and 18 other seed plates are also available. Weight: 70 pounds.

Model KK-310 Row Marker and Model KK-320 Fertilizer Hopper (for use with the KK-305 Planter)

The KK-310 Row Marker helps maintain desired row spacing by marking next row as you plant. It is adjustable for different crop spacings. The KK-320 Fertilizer Accessory, when added to the KK-305 Planter, enables you to plant and fertilize in one operation. The rate of fertilizer flow can be regulated. Weight, Model KK-310: 10 pounds; Model KK-320: 20 pounds.

Brinly-Hardy Co., Inc.
P.O. Box 1116
Louisville, KY 40201

Ventura Large Seed Planter

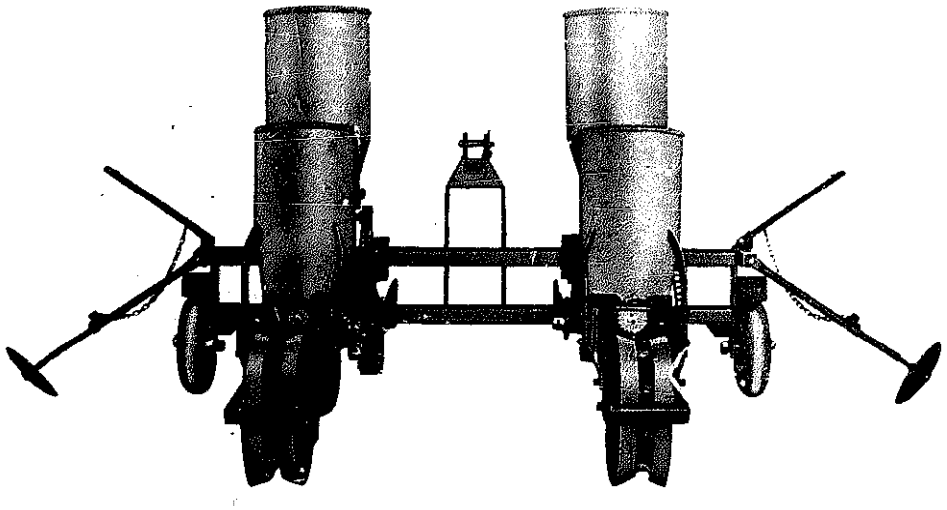
This is a single-row planter which fits onto any tractor tool bar. The seed wheel revolves through the reservoir of seed, picks up one seed at a time, and deposits it into the planting opener. There are 12 different wheels for planting different-sized and -shaped seeds.

Ventura Mfg. & Implement Co.
1265 Commercial Ave., P.O. Box 1069
Oxnard, CA 93030

Jumil J-2 Unit Planter

Available with semiautomatic furrowers, this equipment furrows, sows, and fertilizes all in one operation at any required depth and spacing. The units themselves or the tool bar to attach them is furnished with three-point connections adjustable to any type or make of tractor. Discs are furnished to plant corn, cotton, rice, and peanuts. Special adapters are available for planting soybeans.

Jumil
Justino de Morais, Irmaos S.A.
Rua Coriolano 380, Sao Paulo S.P., Brazil



Jumil J-2 Unit Planter
Jumil

Gandy Row Seeders

Gandy makes a number of row seeder units with gear drives from a 12- or 6-volt electric motor or hydraulic motor drive. They have seeders for every major brand of farm equipment in all sizes.

Gandy Co.
528 Gandrud Rd.
Owatonna, MN 55060

Models 202-202F, 404-404F

The 202-404 planters for sowing cotton, corn, sunflower, melon, and sorghum seeds consist of separate T-63 sowing units which are attached to a rhomboid 2¼ by 2¼-inch tool bar. The units can be adjusted to a width of 16 inches to suit the required width between rows. The planter is made in three variations for two, four, or six rows. It is equipped with automatic markers fixed at a certain angle to ensure the creation of a prominent furrow that will mark the rows for the next pass. The marker works simultaneously with the elevation of the planter by the tractor operator. These markers can be set to suit different distances. The planter is equipped with front shovels mounted on a special front bar, to remove dry earth before sowing. Covering discs or shovels are optional. Other models are available, including those specially designed for planting sugar beets, vegetable seeds, onions, garlic, and peanuts, as well as multipurpose units.

Technohar Agricultural Machinery & Implements, Ltd.
New Industry Region, Petakh-Tikva
P.O.B. 225, Israel

Heath Precision Vacuum Planter

The seeds are picked up by means of a vacuum and held to the small holes in the plate, which is driven by the presswheel. An easily adjustable, graduated selector avoids doubling in case two seeds are picked up by the same hole. When each seed arrives near the lowest point, the vacuum stops abruptly; the seed is released and falls. The plate operates above the furrow opener and drops the seeds approximately 3 inches apart. The absence of mechanical handling means gentle treatment of the seeds, assuring maximum germination, which is especially important in beans. Planting depth can be easily controlled by a single handle which simultaneously adjusts the level of the two wheels. The fan is mounted on the tool bar and is connected to the tractor PTO which should be operated at 540 rpm. (A 1,000 rpm conversion kit is available.) The fan provides enough vacuum for up to 12 units. The vacuum's fine adjustment is controlled by the fan shutter, and a vacuum meter is connected to the fan. The planter is suitable for all row crops: sugar beets, cotton, corn, beans, sorghum, sunflowers, melons, watermelons, cucumbers, tomatoes, peppers, onions, cabbage, and broccoli, as well as coated seeds such as lettuce and carrots.

Features of the 925, as described by the manufacturer, include:

1. Precision planting with exact spacing.
2. Accuracy is maintained even at high speed; up to 50 seeds per second can be planted.
3. No grading is needed even with seeds of irregular shape and size.
4. No pelleting is needed for small seeds.
5. Changing the seeds or the seed plate and cleaning are very easy. The same seed plate is used for a variety of seed sizes.
6. A higher percentage of single seeds is dropped than with any other planter.
7. A zero pressure tire prevents mud from building up.

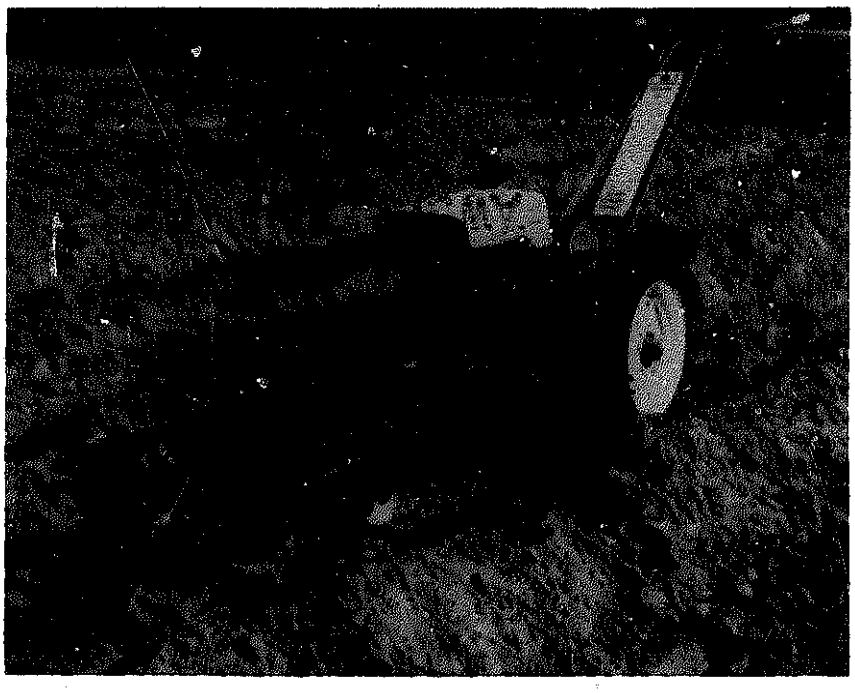
Seed spacings from 1.25 to 20 inches are easily obtained by changing a sprocket on the drive chain or the seed plate. The 925 is made up of unit planters. Up to 12 can be mounted on the heavy-duty tool bar with row spacings easily varied. The minimum spacing is 16 inches. The furrow openers are twin offset discs with a shoe to form the furrow. The discs cut away trash while the shoe firms and packs the sides and bottom of the furrow. Positive fin-type furrow closers are used. A furrow depth adjustment can be achieved without changing the level of the planter.

Heath Farm Equipment
125 S. Airpark Dr., P.O. Box 312
Fort Collins, CO 80522

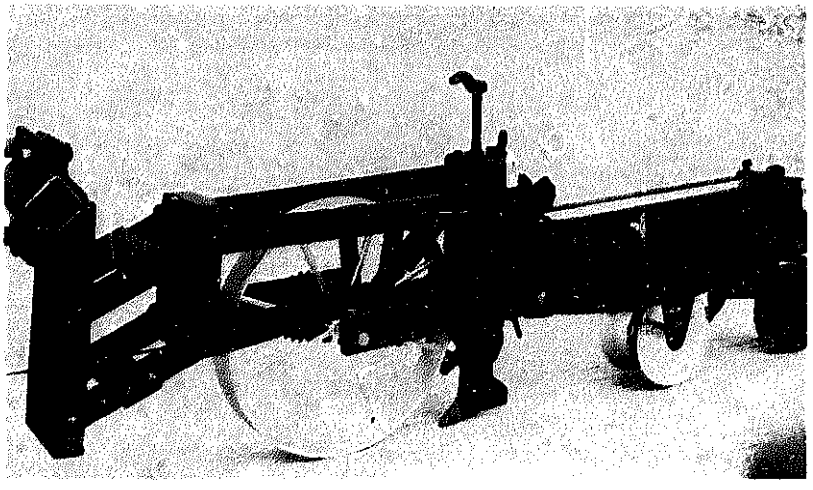
ALMACO V-Belt Planter-Applicator

The V-belt planter-applicator can be supplied as a completely assembled unit, with mounting brackets in place of adjustable handles and rubber-tired running gear. The unit can be attached to power-driven equipment such as garden and riding tractors, or mounted on tool bars for single- or multiple-row planting or application of granular materials. Mounting brackets can be furnished which automatically adjust to the contour of the soil, thus assuring uniform depth of planting.

Certain parts of the planter-applicator such as the planter frame, V-belt pulleys and shafts, slanting, metal-covered hopper sides, metal apron, sprockets and drive chain, sliding gate, and smooth or ribbed-style V-belts can be special-ordered for different applications in mounting on power-driven equipment.



ALMACO V-Belt Planter-Applicator attached to the front end of a two-wheel tractor.
Allan Machine Co.



ALMACO V-Belt Planter-Applicator ready for mounting on a toolbar.
Allan Machine Co.

Allan Machine Co.
P.O. Box 112
Ames, IA 50010



Five ALMACO V-Belt Planter-Applicators mounted on a toolbar for planting five rows at one time.
Allan Machine Co.

Pneumatic Discharge Seeders

Dr. Giovanni Benati
37100 Verona
Via C. Battisti, Italy

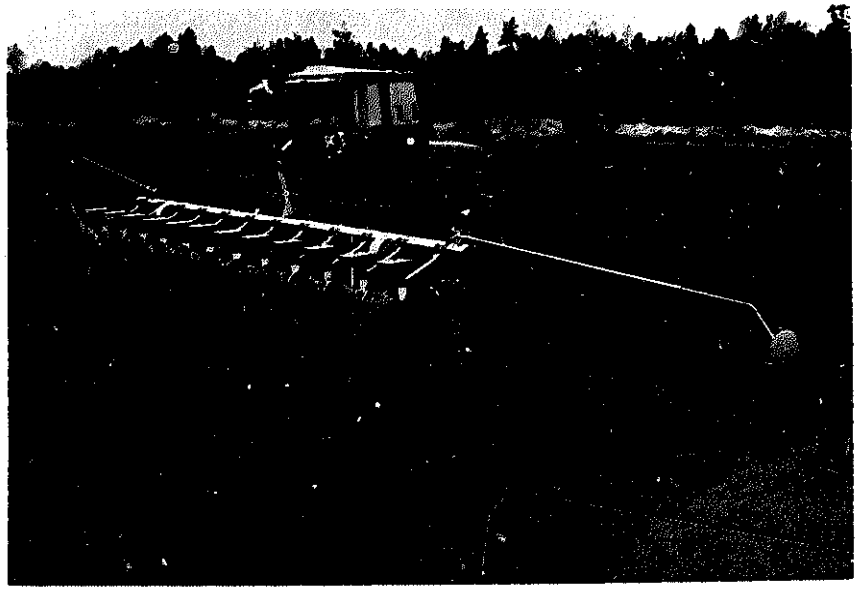
Tanzania Agricultural Machinery Testing Unit
P.O. Box 1389
Arusha, Tanzania

Nibex Unit Seeder

The flexible Nibex system incorporates an original cup-distribution technique which is ideal even for planting irregularly shaped vegetable seed, which formerly was difficult or impossible to sow individually. The system includes 25 types of cups for most seeds, both natural and pelleted. This wide range makes it possible to choose a suitable cup for each desired drilling method. The seeding rate can be varied from four to about 2,000 seeds per running yard—either thin-line or band-drilled over a width of 2.5 or 4 inches (65 or 105 millimeters). The cup system is largely unaffected by variations in seed size, and seed cup discs are quickly interchanged for different crops.

The furrow is formed so that the seeds are immediately covered by a thin layer of moist earth. The coulter sideplates prevent dry surface soil from filling the furrow before the presswheel presses the moist earth into direct contact with the seeds. The furrow is next covered with loose earth, and conditions are now ideal for growth. The adjustable skid and the weighted presswheel allow a constant drilling depth to be maintained, even on loose and uneven surfaces.

The stainless steel coulter gives maximum wear resistance and prevents earth from sticking to it, even in wet conditions. Wheel brackets, seeder units, and marker brackets can be positioned anywhere on the beam, making the row spacing progressively variable from 7.5 inches (20

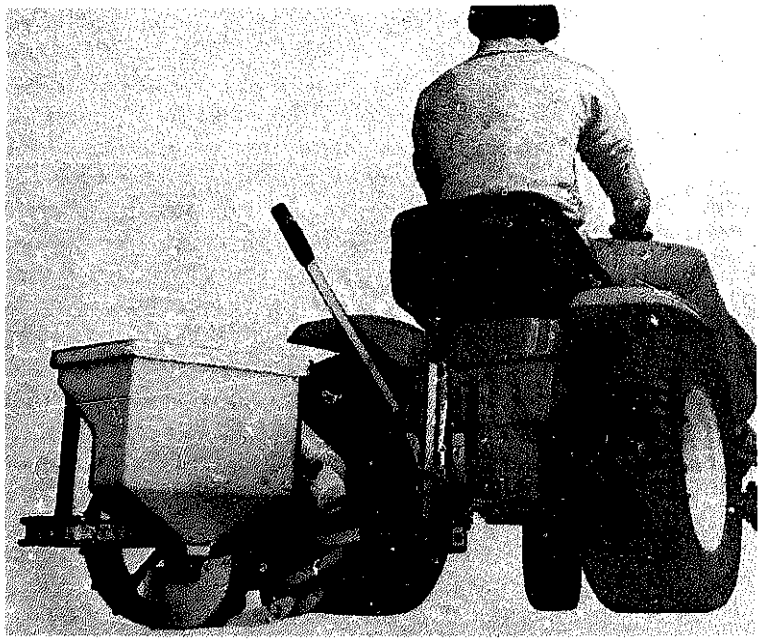


Nibex Unit Seeder
Nibe-Verken AB

centimeters) and upwards. (The rows can be brought closer together by attaching the unit sideways and driving back and forth in the same wheel tracks.)

Nibex unit seeders come in two- to twelve-row units; each unit has a 5-quart hopper capacity. Three-chain transmissions and a six-speed gearbox offer a choice of 18 settings. Normal operating speed is 2 mph; 3 is maximum. Depth is adjustable from 0 to 2 inches (0 to 5 centimeters). With 20-inch row spacing, a three-row machine will seed approximately 1.25 acres per hour.

Nibe-Verken AB
S–285 00 Markaryd
Sweden



Esmay Unit Seeder
Esmay Products, Inc.

Seeder-Fertilizer Garden Tractor Mount

This unit was specifically designed for the truck farmer and larger home gardener. One pass opens the soil to the desired depth, seeds, fertilizes, and covers the seedbed. It attaches to standard hitching devices, category 0, three-point, drawbar, or sleeve hitches. Of corrosion-proof construction, it comes with seven seed plates which plant more than 20 common vegetable seeds.

Esmay Products, Inc.
P.O. Box 547, Maple St.
Bristol, IN 46507

GRAIN DRILLS*

* Reprinted in part from *Small-Scale Grain Raising* by Gene Logsdon. Rodale Press, 1977.

For planting seed in solid stands rather than in rows, a drill is used. For small acreages, however, you can often use small broadcasters much more efficiently, even counting the light disking or harrowing necessary to cover the seed. Generally speaking, the drill gives more precise planting depths than broadcasting and harrow covering and will result in better germination, especially if dry weather follows planting. The drill puts seed into the ground more or less continuously rather than depositing a precise number of seeds at precise spacings the way a row seeder does. It is used for cereal grains and grasses, and sometimes for soybeans if a solid stand is desired. Essentially, the drill is a long planting box with openings every six inches or so, from which planting tubes lead to the disc openers that run into the ground at planting depth. The discs open a shallow trench for the



A team of horses could plant 20 continuous rows of grain with this 19th century drill.
Farm Implement News, 1897

seed and close the trench on the seed after it falls. On old drills, a small length of chain drags behind each disc to aid in covering the seeds. The seeds are actually planted in rows, just inches apart, and when the grain gets to be about six inches high the plants grow together, giving the impression of a solid stand.

Normally, you can save quite a bit of money buying an old planter if it is still in working order. Be sure the planting plates come with it or can still be purchased. This is not usually a problem now because very cheap plastic plates are made to fit most planter boxes. In fact, the plates are given away by seed corn dealers when they sell a farmer his seed. The seed dealer wants a satisfied customer and the plastic plates he has are made specifically for the size kernels he sells—a different one for whatever plant population the farmer wants. But it is possible that on old and rare planters which you might find by chance, the plates wouldn't be a standard size. Before purchasing an old planter, it's always wise to make sure it has plates with it or find out where you can obtain new ones. Most of the common, older drills plant a swath of seven feet in one pass—about the right size for a homestead.

Seeding rates can be regulated by controls under the seed box. The seed box may be divided into two compartments, each side of which has its own control. Charts on the inside of the hinged box lids give instructions on setting the adjustments for different seeding rates. On old drills you will have to experiment by putting a measured amount of grain in the box, then planting a known, specified acre (or a portion thereof), and then see if the actual planting rate corresponds to what you have the drill set for. Compare and compensate accordingly. Those old cogs wear and may not work as precisely as they did when the drill was new.

Many drills, even old ones, have fertilizer



A single-point, tractor-drawn seed drill with fertilizer drill—about the right size for the small farm.

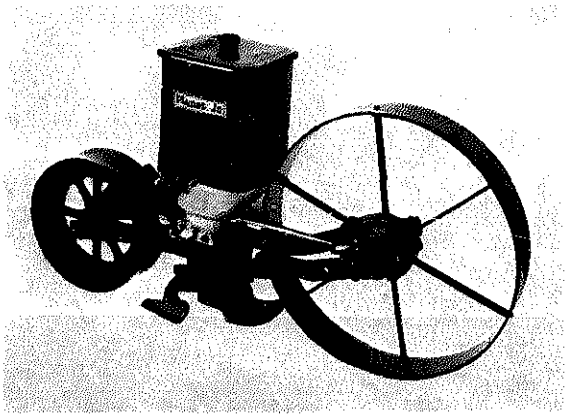
boxes just in front of the seed boxes. Unless they are well taken care of, the fertilizer boxes may be badly corroded or completely ruined. This will not necessarily stop you from using the drill, but you won't be able to fertilize as you plant. As another special feature, some drills have special smaller boxes for clover seed so that when planting spring cereal crops like oats, the farmer can sow clover right along with it.

SOURCES OF TRACTOR-DRAWN DRILL SEEDERS

Planet Junior 7135X Drill Seeder

A versatile planter with interchangeable seed plates for drilling vegetable seeds of all sizes. Special attachments are available for adapting the unit to field crops.

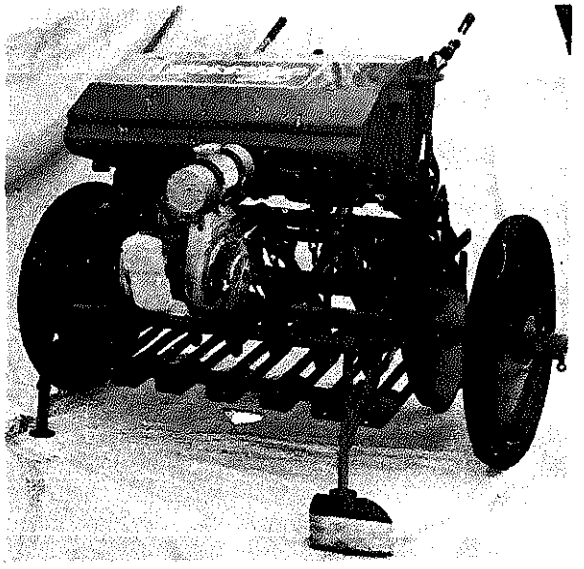
Planet Junior Division
Piper Industries
P.O. Box 1188, Freeport Center
Clearfield, VT 84106



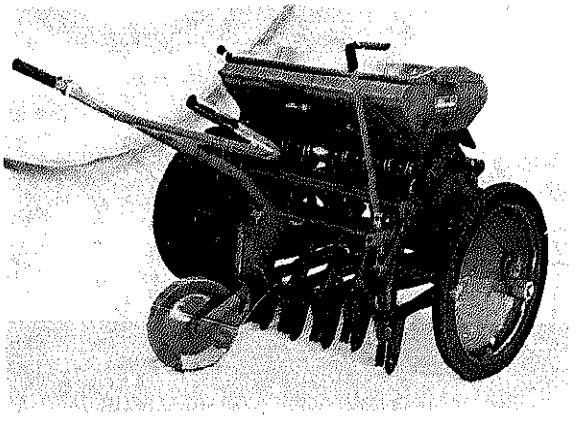
Planet Jr. 7135X Seeder
Piper Industries

Hassia Model PS Plot Drill

The Hassia Model PS is a small plot drill with four, five, seven, or nine hoe-type openers. A fluted wheel meters the seed from either a single or a number of individual hoppers to isolate the runs. It is particularly designed for the precise nature of research work. The drill can be supplied with a tractor hitch, can be animal-drawn, or propelled by a 2½ h.p. gasoline engine. The centrifugal clutch on the motorized model enables the operator to set the



Hassia PS Plot Drill with gasoline engine: Front view Rear view
H. J. Troster



accelerator to any walking pace. The unit is designed with even weight distribution for simple steering and handling.

A.J. Troster Landmaschinenfabrik
6308 Butzbach, Oberhess
Postfach 240, West Germany

MppD Monoseed Drill for Tubers

This unit is a hand-fed, double-drill, tuber-sowing machine. Sowing depth and row width as well as the depth of the covering layer are adjustable, by means of convex clutch discs. Fertilizer dispensers are optional extras, and the unit is attached to the tractor by a three-point hitch.

Fratelli Deidone, Macchine Agricole
C.C.I.A.N. 59212, Casella Postale 7
Villafranca DiVerona, Italy

Zita Sowing Machine With Fertilizer Distributor

Even when fully loaded, this machine is light enough to require only 1.6 h.p. to pull each drill (this model unit has seven drills). The seed tank is separated into two parts for seed and fertilizer, and each section can be regulated separately. The gear-type feeders for seed and fertilizer maintain a steady application rate independent of tractor speed. The Zita sowing machine can be operated by the tractor operator or by a second person sitting behind the unit.

Sons Ath. Zafiridi Industry of Machineries, Inc.
Langada 4.5 km. T.T.7
Sevroupolis, Thessaloniki, Greece

Hindsons Seed-Cum-Fertilizer Drill

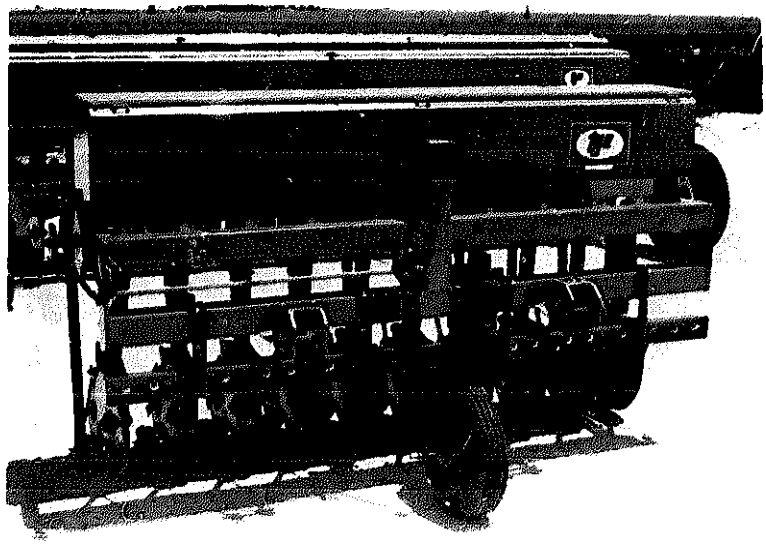
Planting four rows at a time, all kinds of seeds can be precisely placed at a comfortable distance away from the fertilizer. The distance between furrows is adjustable with spring-steel tines. Construction of the unit was designed for simplicity, light weight, easy cleanability, and the drill can be pulled by most any tractor with a lift arrangement.

M/s. Hindsons Private, Ltd.
The Lower Mall
Patiala, India

Tye Soybean Drill

Not only for soybeans but wheat and other small grains as well, this drill is available in many sizes, the smallest is a two-row or 6.7-foot model. It is attached behind a tractor by a three-point hitch, has adjustable spacings, accurate seed metering, and positive depth control.

The Tye Co.
Box 218
Lockney, TX 79241

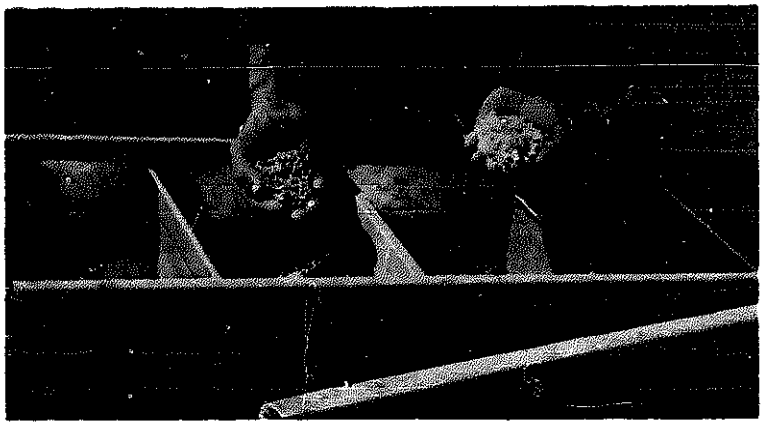


Tye Adjustable Drill, 80" model
Tye Co.

IRRI Multihopper Seeder

The IRRI Multihopper Drill Seeder for upland use is designed with a divided hopper for interplanting several crops simultaneously. It can be pulled by either a two- or four-wheeled tractor.

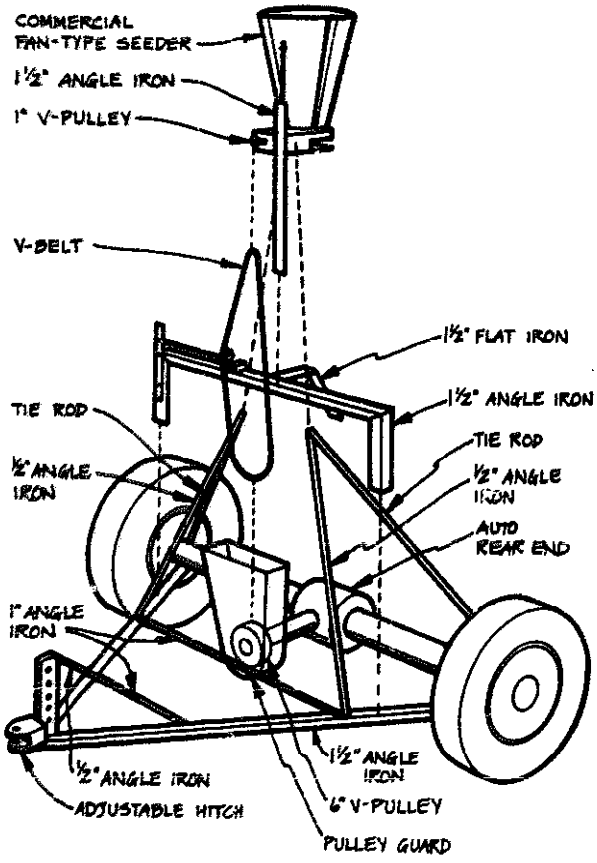
International Rice Research Institute
P.O. Box 933
Manila, Philippines



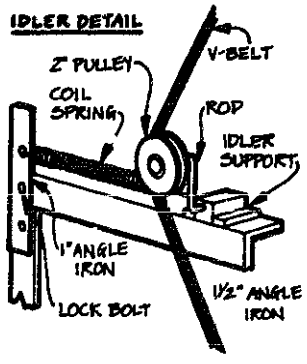
The multihopper seeder holds different kinds of seeds for interplanting crops.
International Rice Research Institute

The multihopper seeder being pulled by a two-wheel tractor.
International Rice Research Institute





This basic design for a homemade seeder with hopper, idler, wheel assembly and hitch was developed by the Texas Agricultural Extension Service of the Texas A & M University System in College Station, Texas.



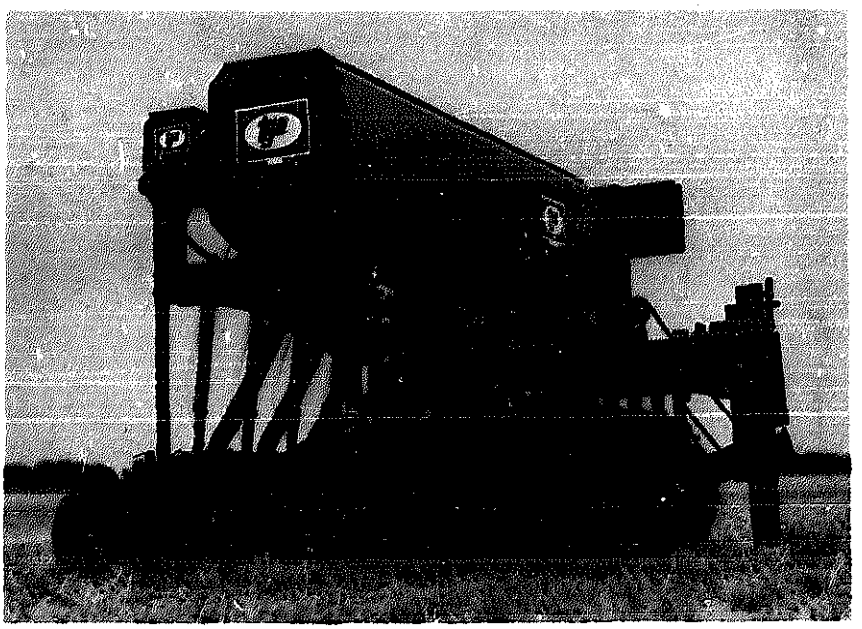
NO-TILL PLANTERS

Sometimes called a pasture renovator, the no-till planter is a seed drill with a special function. It is supplied with a disc and a shoe which allow it to slice the turf and plant a seed without first plowing and preparing a seedbed. Animals can continue to graze while new plantings of clover or grass get started. One farmer reports, "I get a lot of nitrogen this way and I get it where it counts." According to Dick Margulis, who writes advice for novice farmers in *Countryside*, "Good natural nitrogen in the plant means good natural protein for the cow. A farmer ought not to buy his nitrogen or his protein. His total farm cycle ought to handle the greatest share of this problem." Also, planting in existing sod is a very good practice to control erosion.

The Tye Pasture Pleaser

The Tye Pasture Pleaser is a compact three-point-hitch-mounted, no-till planting unit covering 80 inches, with disc units spaced 10 inches apart. It is a conveniently sized tool for seeding legumes, grass, or small grains in sod, permanent, or improved pasture. Drive is by a single, spring-loaded, front-running coulter. Each double-disc unit is preceded by a spring-loaded coulter blade. Each blade, as well as each disc unit and press-wheel, is individually hinged and spring loaded for work on uneven ground. The larger hopper is fitted with internally fluted seeder units for small grains as well as soybeans. The small hopper or grass box is fitted with externally fluted seeder units for dispensing grasses and legumes. Brackets are provided for adding suitcase-type weights to assist penetration of the coulters in hard ground.

The Tye Co.
Box 218
Lockney, TX 79241

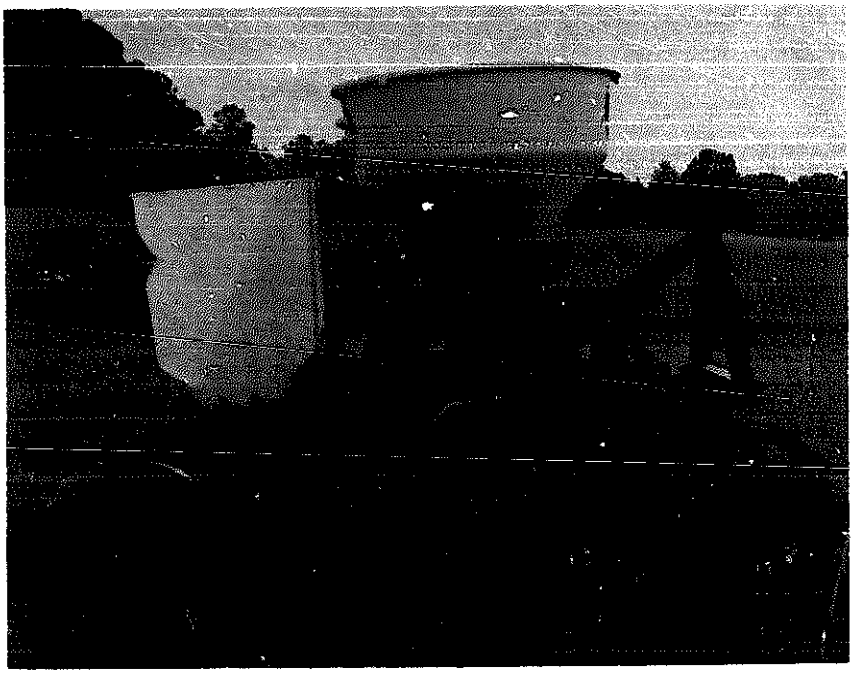


Tye Pasture Pleaser
Tye Co.

Cole No-Till Planter

The Cole No-Till Planter has a double-disc seed opener which cuts straw and debris in the field, preventing trash buildup in front of and under the seed opener. Included is a heavy-duty swivel coulter—a chisel plow which automatically resets after being tripped. You get a choice of three seed hoppers:

1. Edgedrop with 1-bushel capacity
2. Uniplex with 1-bushel capacity and single, inclined seed plate



Cole No-Till Planter
Cole Mfg. Co.

3. Duplex with dual, inclined seed plates and 2-bushel capacity.

Fertilizer attachments which place fertilizer 4 to 6 inches deep in the slit opened by the chisel plow come with the ground-drive wheel and 250-pound capacity fiberglass fertilizer hoppers. Granular chemical applicators which put out herbicides or insecticides or both are also available. The planter also comes in four- and six-row models.

Cole Mfg. Co.
1318 Central Ave
Charlotte, NC 28299

TRACTOR-DRAWN BROADCAST SEEDERS

Power to turn the mechanical rotating distributor of a broadcast seeder can be supplied either by power take-off from the tractor or by a ground-drive wheel. (The distributing mechanism is basically the same as that of the hand-cranked broadcast seeder, which we discussed earlier in this chapter.) With no power source, animal-drawn distributors rely on a gear drive from the ground wheel to the rotating wheel to rotate the distributor. The newest units are battery-operated so that the distributor can be attached to any moving vehicle, whether it's a tractor, jeep, or automobile.

SOURCES OF TRACTOR-DRAWN BROADCAST SEEDERS AND SPREADERS

Ezee Flow Model 105 Spreader

They call it a turf care model, but this 310-pound unit with a 7.7 cubic foot, 500-pound hopper capacity falls into the small farm category for us. With a 54-inch-wide coverage, this unit is ground driven and requires a minimum of 10 h.p. to pull it. The spreader is calibrated for seed as well as fertilizer distribution.

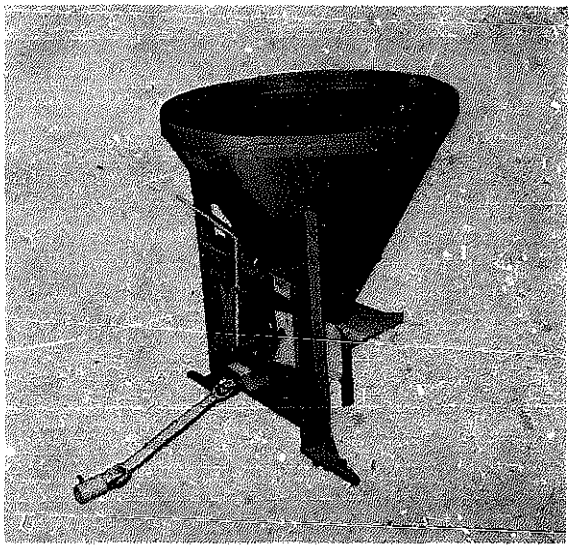


Ezee Flow No. 105 Spreader
Avco Corp.

Ezee Flow Number 113 Broadcast Seeder

With a 3-bushel (2-bushel extension available), galvanized steel hopper capacity, this 81-pound broadcast seeder spreads up to 36 feet. The spread is controlled from the tractor seat. The unit requires a minimum of 18 h.p., a three-point hitch, and a universal-joint PTO drive. Larger units are also available.

Ezee Flow, AVCO Corp.
First & Sycamore
Coldwater, OH 45828



Ezee Flow No. 113 Spreader with three-point hitch mounting and universal PTO shaft drive.
Avco Corp.

Wikomi Electric Broadcast Seeder

You can attach this electric seeder to your truck, jeep, or car—a tractor is not necessary, just a 6-volt battery. With a 1½-bushel capacity and an optional 1-bushel extension, you can plant 20 acres per hour. Larger units are available.



Wikomi Electric Broadcast Seeder
Wikomi Mfg. Co.

Wikomi Poly-Hopper Seeder-Spreader

A new product in their lawn and garden line, the 1-bushel seeder, 100-pound fertilizer spreader constructed of polyethylene fits most lawn and garden tractors and riding lawn mowers. It has a 12-volt electric drive, mounts on a rear drawbar, and weighs 28 pounds. Larger units are available.

Wikomi Mfg. Co.
P.O. Box 100
Litchfield, IL 62056

Sears Spreaders

The smallest unit Sears lists has a 1-bushel capacity. It bolts to a standard tractor drawbar and is powered with a direct drive PTO. It has an 18-gauge welded steel hopper and spreads a swath up to 50 feet wide. Weight: 37 pounds.

Sears, Roebuck & Co.
Farm and Ranch Catalog

Apolo Broadcaster

With a capacity of 400 to 450 kilograms, this fully adjustable unit operates from the power take-off shaft of a tractor. The recommended application speed is 7 to 12 kilometers per hour.

Industrias Metalurgicas Apolo S.A.
Carrera 50-2 Sur–189 Autopista Sur
Medellin, Antioqui, Colombia

Lely

Lely makes broadcasters for a tractor PTO with hopper capacities ranging from 8.5 to 156.4 bushels.

Lely
Box 1060
Wilson, NC 27893

Gandy

Starting with a 3-foot long, 1.6 cubic foot hopper, Gandy has tractor-drawn, wheel-driven spreaders for seeding or fertilizing.

Gandy Co.
528 Gandrud Rd.
Owatonna, MN 55060

106 Single Spinner

New Idea's smallest model spreader-seeder (No. 106) has a 12-gauge steel hopper capacity of 690 pounds and an effective spread width of 36 feet. Density of coverage ranges from 4 to 1,570 pounds per acre. It attaches to a tractor by a three-point hitch.



New Idea Seeder No. 106
Avco Corp.

AVCO Corp.; New Idea Farm Equipment Div.
First & Sycamore
Coldwater, OH 45828

Diadem Precision Spinner Spreader and Seeder

Attached with a three-point hitch, the Diadem comes with 7-, 9-, or 12-bushel capacities.

Vandermolen Corp.
119 Dorsa Ave.
Livingston, NJ 07039

Gherardi Fertilizer Broadcaster

Although this spreader is suitable for most types of fertilizer, it was designed chiefly for high-concentrate, granulated, pulled, or semi-pulled fertilizers requiring a high degree of accuracy. Traveling speed can range from 3 to 16 kilometers per hour. Two sizes are available: a 75-kilogram model with a 300-liter capacity, and a 130-kilogram unit with a 500-liter capacity.

Gherardi
Officine Macchine Agricole Industriali
Jesi (Ancona) Via Gallodoro 68, Italy

Midjet

The Midjet is a small, tractor-drawn, broadcast seeder-fertilizer designed as a lawn tool, which hitches to a small garden tractor.

Champenois
Chamouilley
52170 Chevillon, France

PLANTING BY SYSTEMS

CHECK-ROW PLANTING

by Roger Blobaum

The check-row planter, an implement widely used on Corn Belt farms for more than 60 years, made possible the kind of mechanical weed control that many small farmers want.

The check-row planters, which disappeared along with work horses on most farms in the 1930s and 1940s, dropped seed corn in hills spaced about 30 inches apart each way. Their main limitation was that they could not be used on fields that were contoured or laid out in other ways that did not provide straight rows.

This checkerboard pattern made it possible to cultivate fields both ways, giving excellent results. This kind of cultivation threw dirt up around all sides of the corn hills and took out the weeds, both in and between the rows. It provided much better weed control than modern implements, which are unable to reach weeds between the plants in drilled rows.

The precise planting pattern was made possible by wire buttons spaced usually 40 or 42 inches apart on a check wire anchored with a stake at each end of the field. The stake had to be moved over by hand each time the planter came to the end of the row. The check wire passed through the planter as it moved across the field. The buttons tripped the plates in the seed corn boxes, dropping bunches of kernels in uniformly spaced hills.

Cultivators in that period had shanks that were guided by the farmer's feet. The shanks made it possible to guide the shovels around any hills that ended up slightly out of line in the checkerboard pattern. This arrangement was much more flexible than cultivators mounted on the tractors that were replacing horses on most farms.

The careful two-way cultivation made possible by check-row planting became less important when farmers began applying chemical weed killers. Fast-moving tractors and equipment that planted four or six rows at a time also helped bring about the switch to planters that drilled corn in rows and mounted cultivators that moved across these fields at much higher speeds.

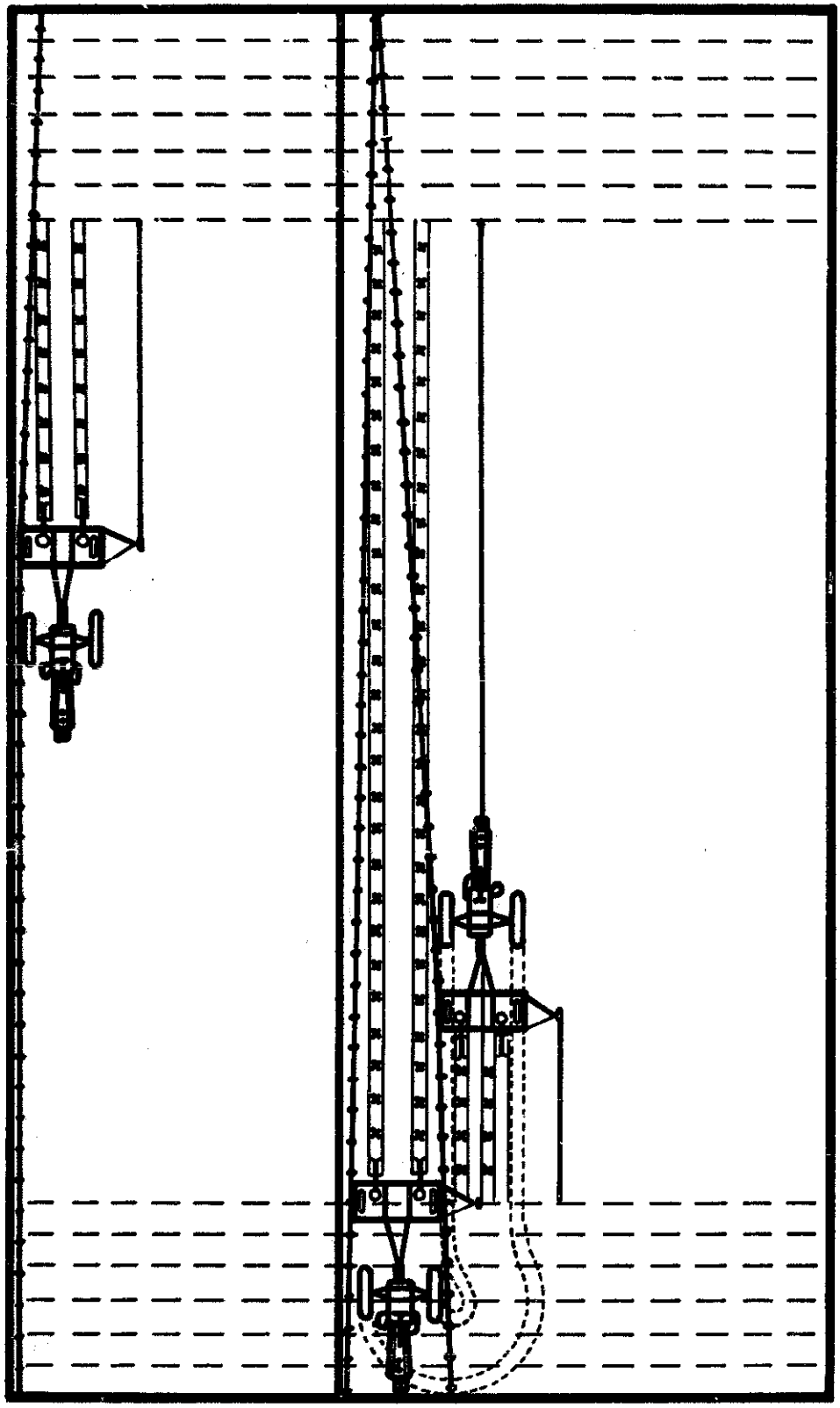
The introduction of four-row check planters caused some problems. Scientists at Iowa State College in the early 1930s solved one of them—the tendency of these planters to pull check wires

The Check-Row Technique:

check wire with buttons

marked guide for next row

xxxxxxxxxxx plantings

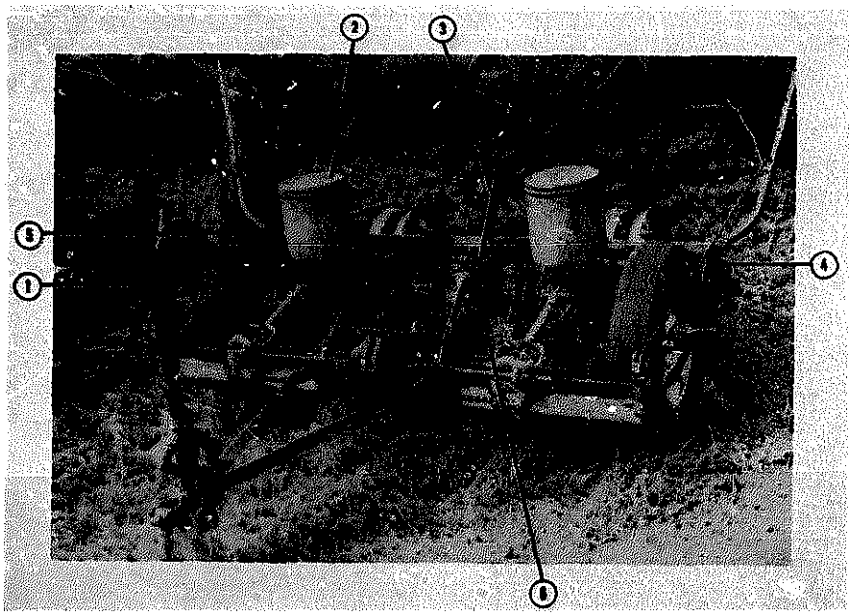


Checking

1. *After planting two or three rounds, stop and dig up about eight cross-rows to see if cross check is good.*
2. *If cross check is not accurate, adjust checkheads as necessary to correct cross check.*

Turning at Ends of Field

1. *Pull trip rope about nine buttons from the end. This will automatically release wire about seven buttons from the end.*
2. *Turn planter in position for planting the next two rows, stopping squarely over mark.*
3. *Move anchor stake behind runner on wire side. Set tension the same each time wire is moved.*
4. *Drive forward, keeping tractor straight over mark.*



Parts of a check-row planter: 1) lever (arm); 2) seed hopper; 3) power lift control; 4) checkhead; 5) automatic release; 6) power lift clutch. Ron Krupicka

out of line at the ends of the rows. A report presented in Chicago in 1933 described the development of the new pay out planter stake and concluded that it would eliminate this problem.

Although tractor-mounted planters were available, the Iowa State experiments utilized a pull-type planter so a tractor-mounted cultivator could be used at the same time. This made it possible to cultivate the seedbed just ahead of the check-row planter, giving the corn a better chance to get a jump on the weeds.

"We are so well pleased with the results of this combination that we feel justified in suggesting the desirability of designing planters so that this combination can be made by the user," the Iowa State report declared.

"It can be accomplished either by using a pull-type planter or by mounting the planter on the rear of the tractor in such a way that it will not interfere with the cultivator mounting."

Another report prepared by a Deere & Co. manager in 1944 described a high-speed check-row planter that was adapted to tractor power. The new design permitted the planter to push the corn kernels out of the seed box instead of using a mechanism that kicked or batted them out. It was seen as an important development in the transition from horses to tractors.

"This development, which has made it possible to speed up greatly the operation of planting corn, is an engineering achievement of much significance," the report said. "It is of inestimable value to the farmer in enabling him to plant his corn under more favorable weather and soil conditions."

The check-row method also was used to plant cotton, allowing cross-cultivation and eliminating the need for much of the labor-intensive hand hoeing and thinning that had been commonplace in the South for a century or more.

"Hill planting, cross harrowing, and checkered tillage practically eliminate the hoe as a weapon for killing grass and weeds and render hand thinning unnecessary, except in an occasional hill where the plants are too numerous," a 1929 report from the Arkansas Agricultural Experiment Station pointed out.

"The release of much hand labor from the acreage of cotton customarily cultivated will afford more time to till an increased area."

We haven't seen check-row equipment around for over 40 years, but this equipment is certainly something anyone farming with horses should investigate. For the organic farmer, check-row planting

is one way to completely devastate a population of weeds without the use of herbicides. Granted, fields cannot be as densely planted, but there is growing controversy over the importance of high-density planting, and with sparse plantings, there is more room for interplanting other crops like pumpkin and squash between the plants.

Back in the early 1930s, results reported in *Agricultural Engineering* * showed that production yields of cotton could be kept up by planting in the check-row fashion with more densely planted hills rather than distributing seed throughout the row with a drill, even with fewer plants per hill. Fueling the controversy is the escalating price of seed grains. Here are some sound arguments for check-row planting that were set forth in the article:

1. On bottom land, or on other lands of a high degree of fertility, cotton seems to produce as well when the plants are grouped in hills arranged for cross-cultivation as when the plants are distributed in rows.
2. Thickness of planting in hills appears to accomplish the same result in stimulating earliness as has been shown for close spacing in the drill.
3. No exact number of plants to the hills seems necessary. According to results, the number can range from two to six plants per hill or around 10,000 to 25,000 an acre. However, since the production was lowered less with 15 plants to the hill than with one plant to the hill, the stand maintained should be nearer the upper limits of the range of highest yields rather than toward the lower side of this range.
4. Hand thinning is unnecessary.

CHECK-ROW PLANTING ALIVE AND WELL IN NEBRASKA

by Ron Krupicka

Editor's note: Ron is Codirector with Dennis Demmel for the Small Farm Energy Project at the Center for Rural Affairs in Hartington, Nebraska. This story is about his uncle.

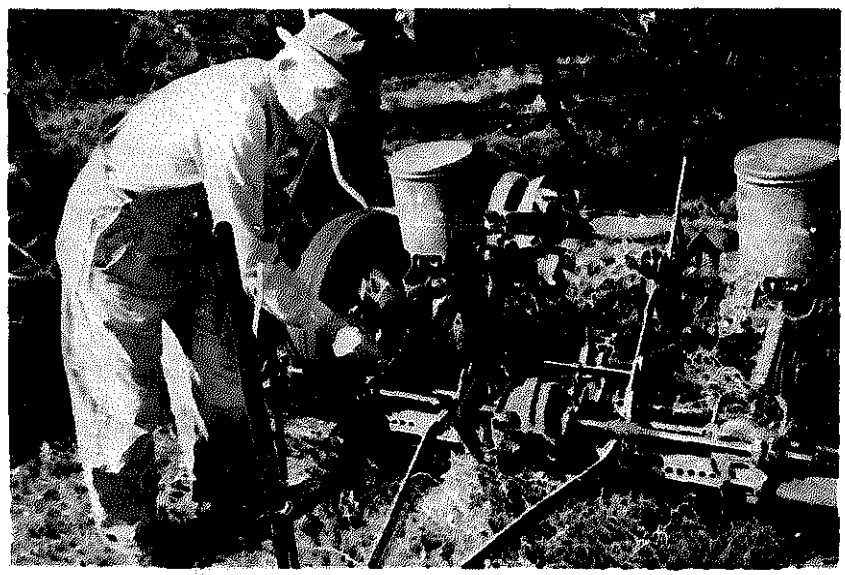
Louis Suchy, 72, has been farming his 320-acre, diversified farm near Niobrara, Nebraska all his life. He has always used a check-row planter for planting his corn. At first he used a horse-drawn check planter. Today, however, he uses a tractor-drawn, two-row, check-row planter he purchased at a local farm sale.

Louis' first step when planting with a check-row planter is to string a wire with buttons across the field from one end to the other. The wire is laid with just the right amount of slack so that it can be fitted in the guide located on the side of the planter. As the planter is pulled across the field, the wire passes through the checkhead and the buttons which are set every 40 inches on the wire trip a mechanism that turns the planter plate, allowing either two or three seeds to drop.

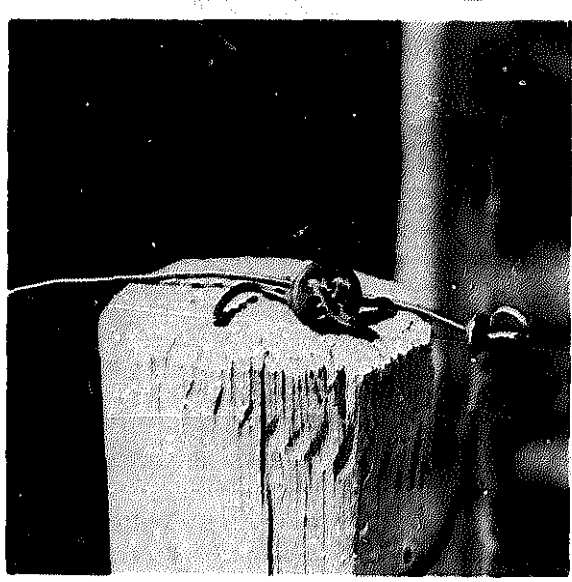
Louis has 16-hole plates in his planter which will drop three kernels to a button. But he feels that moisture is a limiting factor in his area and three kernels per hill would increase his plant population to the point where there wouldn't be enough water to supply all the plants. So Louis plants first two kernels, then three kernels in alternating hills. To do this, he has sealed up two holes on each plate by welding them shut.

To plant the corn, the planter is drawn down the row dropping two or three kernels in hills every 40 inches. After planting two or three rounds, the cross check is inspected by digging up about eight cross-rows to see if the check is good. If the check is off, the checkhead can be corrected by making the appropriate adjustments as explained in the instruction manual.

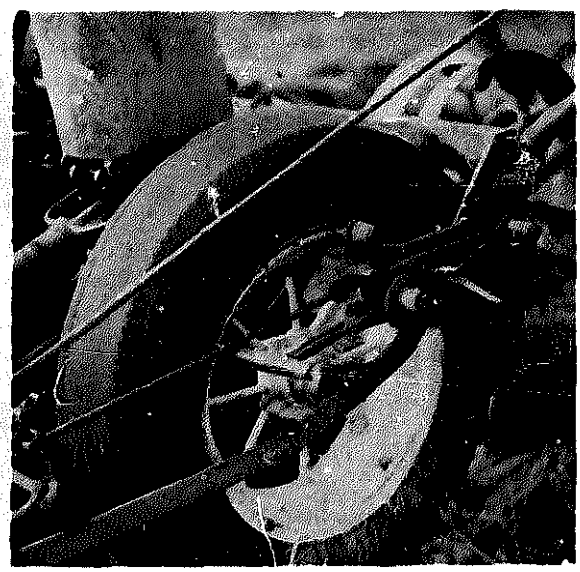
* Ware, J. O. The Hill Planting of Cotton and Checker Cultivation with Large Tillage Instruments. *Agricultural Engineering.* Vol. 11, no. 5, May 1930.



Louis Suchy with his check-row planter. Here he points to the trip mechanism which is engaged when buttons on the guide wire pass through the checkhead.
Ron Krupicka



Check-row buttons got their name when metal buttons like the one on the left were used years ago. No longer resembling a button, the head on the wire to the right acts as the tripping mechanism for newer models.
Ron Krupicka



The checkhead on a check-row planter. The buttons trip this mechanism releasing seeds in one spot.
Ron Krupicka

When the edge of the field is reached, the wire is disengaged and the machine is turned around in a figure eight, thus allowing planting as close as possible to the fence line. The wire is moved over two rows and the process is repeated back and forth across the field. The instruction manual states that six rows must be drilled for the end rows, but Louis' figure eight turn has reduced that to four. When he planted with horses, Louis said he could plant right up to the fence line and, as a result, there was no need to drill the end rows. Also, there was a seat on the horse-drawn planter so that the operator could manually trip the planter to drop the seeds.

Louis noticed that each year the extension service and equipment companies seemed to be promoting a different planting method. He felt that check planting started to decrease when the lister was

pushed. When asked why he still uses the check planter, Louis simply replied, "Dad taught me how to cultivate." It is for the same reason that Louis has never been in his fields with herbicides. He has observed that if you don't follow up spraying with weeding, you will still have weeds.

Louis keeps his fields clean by cultivating three times. The first time he follows the planter, the second time he crosses the planter rows at a 90-degree angle, and the third time he follows the planter again because "otherwise it would be mighty rough picking!" He still picks his corn in the ear with a one-row cornpicker and then stores it in his corncrib.

His average yield over the years has been 50 bushels per acre, sometimes 60—without using any commercial fertilizer on his corn.

PLUG-MIX SEEDING AND EQUIPMENT*

Plug-mix is a method of seeding which incorporates crop seeds and water into a scientifically blended growing medium which is precision placed in the field with a type of jab planter called a hand plugger. Having ⅛- to ¼-cup of loose soil, the seed and compost-nutrient mixture cradles each hill to ensure a uniform, optimum environment for germination and for young seedlings to get off to a good start. It is particularly suited for extensive plantings of most small-seeded vegetable crops.

Advantages of plug-mix seeding over standard seeding methods:

1. A uniform, optimum environment in seed and young seedling zones is provided, along with an adequate, safe level of fertilizer readily available to the seedlings.
2. Plant stands are often better, and seed germination and plant growth are more rapid and uniform.
3. There is no compaction problem with the tilthy plug-mix soil.
4. Fertilizer salt damage during dry periods, and leaching of nutrients during top-water and rainfall are reduced.
5. Fertilizers and seeds are conserved by placement only where needed. This reduces the fertilization of competing weeds.
6. With the automatic plug-mix planter, an economical and successful method of seeding through mulch-covered beds is now available.

Perfecting the plug-mix method involved a joint research project between Cornell University and the University of Florida. Cornell worked on a soil blend while Florida worked on the design of application equipment. Cornell worked with chemicals, but you can arrive at a potent mixture of your own by blending compost, manure, and other organic nutrient sources.

* Reprinted with permission from Fort Pierce Agricultural Research Center *Research Report RL 1974-3*, by Norman Hayslip, Institute of Food and Agricultural Sciences, University of Florida.

AMOUNT OF SEED REQUIRED TO OBTAIN AN AVERAGE OF ABOUT FOUR, SIX, OR EIGHT SEEDS IN EACH ¼ CUP OF LOOSE MIX PER HILL

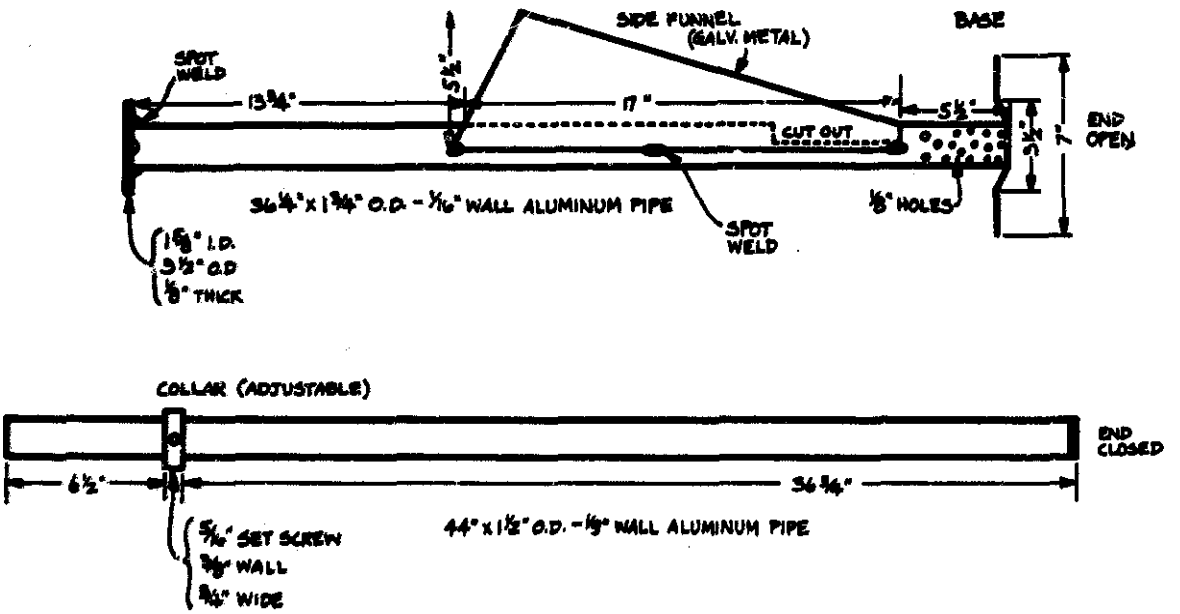
CROP	APPROXIMATE NO. OF SEEDS PER OUNCE [1]	AMOUNT OF SEED (OUNCES) FOR 4-CUBIC-FOOT BAG MIX		
		AVERAGE 4 SEEDS/HILL	AVERAGE 6 SEEDS/HILL	AVERAGE 8 SEEDS/HILL
BROCCOLI	9,000	0.8	1.2	1.6
CABBAGE	8,500	0.9	1.4	1.8
CAULIFLOWER	10,000	0.7	1.0	1.4

(Continued on next page)

CROP	APPROXIMATE NO. OF SEEDS PER OUNCE [1]	AMOUNT OF SEED (OUNCES) FOR 4-CUBIC-FOOT BAG MIX		
		AVERAGE 4 SEEDS/HILL	AVERAGE 6 SEEDS/HILL	AVERAGE 8 SEEDS/HILL
CUCUMBER	1,000	7.2	10.8	14.4
EGGPLANT	6,000	1.2	1.8	2.4
LETTUCE	25,000	0.3	0.4	0.6
OKRA	500	14.4	21.6	28.8
PEPPER	4,500	1.6	2.4	3.2
TOMATO	11,000	0.7	1.0	1.4

[1] James Edward Knott. *Handbook for Vegetable Growers*, rev. ed. New York: John Wiley and Sons, Inc., 1962.

A simple and inexpensive hand-operated applicator was constructed for use in early research trials:



The pluggers were used by some growers with positive results, but high labor costs encouraged the development of an automatic planter.

Mechanical Plug-Mix Planters Number 900M and Number 900

The tractor-mounted automatic planter meters up to ½ cup of loose mix into revolving cups which deliver the mix to the planter pockets. The pockets pierce the soil and deposit the mix at fixed intervals. Presswheels can be mounted behind planter pockets to firm the soil from each side on unmulched beds. The unit works well without presswheels on mulch-covered beds, the pockets punching holes through the mulch as they deposit the mix. The toolbar-mounted planter has operated efficiently at a forward speed of 1 mph and is designed to plant at down-row spacings of 10, 12, 20, 30, 51, or 60 inches.

Mechanical Transplanter Co.
S. Central at U.S. 31
Holland, MI 49423

MECHANIZATION OF FARMING UNDER PLASTIC TUNNELS

Editor's note: This information is extracted from a letter written to the editor by Dr. Y. Alper, who is with the Institute of Agricultural Engineering in Bet Dagan, Israel.

The method of growing in low, plastic tunnels has become very popular in the Israeli agriculture over the last few years. Its main advantage is an early crop of fresh vegetables on the market. Our Institute started working on the mechanization of this method a few years ago.

The synchronized plastic mulching and planting machine was the first machine developed for this purpose. This unit, which seeds, mulches, and perforates the plastic above the seeds in one operation, is manufactured by a local company and is used commercially by farmers.

Low plastic tunnel cultivation is a popular technique for early crop ripening. Early ripening is achieved by this method not only by early planting, but also through the better microclimate conditions and the physical protection of the plants during their first stages of growth. The increasing use of this growing technique created a need for mechanical means to erect the tunnels.

The T-2100, which is fed by straight steel wires, forms the arches and places them into the ground in a continuous operation. The spacing between arches and their height are adjustable. The machine is pulled by a small-size tractor and ground-driven by its own wheels.

An automatic machine for farming and inserting wire arches into the ground was developed and field-tested during the 1976 season. Field-test results were very successful and some units were planned to be operated commercially in 1978.

A wire renewer which straightens used wires for reuse with an automatic inserting device was also built.

The development of these machines is a considerable contribution to the mechanization of growing in low, plastic tunnels in Israel; each of these machines can also be operated separately, according to local conditions.

The Kennco Plastic Machine

This plastic machine covers a formed bed with a 1.5-mil plastic. The machine simultaneously tucks and buries the plastic at the sides just under the outside corner of the bed to insure permanence throughout the crop. Plastic machines can be equipped with gas knives or nozzles to inject gas or liquid herbicides just prior to laying plastic on the bed.

Plastic-laying machines come complete with three-point hitch, seat, hiller blades, and aluminum end plugs. A larger, high-speed machine is also available.

Kennco Mfg. Co.
P.O. Box 1158
Ruskin, FL 33570

WINDFELL FARM: AN EXPERIMENT IN INTERMEDIATE AGRICULTURE

"We want to grow the highest-quality, best-looking organic produce possible and stay competitive with our chemically oriented neighbor," says Steve Talbott, of Banks, Oregon. To do this, he and his father are developing "a workable, efficient, small-scale family farm" that specializes in row crop vegetables. Affectionately named Windfell, the farm doubles as a home enterprise and an experiment in intermediate agriculture.

The key to the Talbott system is a transplanting machine called the Hydro-Synchron, invented and patented by the Talbotts, and a cropping system called Jetspeed. Jetspeed is the registered name for an integrated system of diversified row crop production, using high-quality facilities, machinery, and

tools and an intermediate technology applicable to a small- or medium-sized operation, from 5 to 100 acres.

The system is neither capital-intensive nor labor-intensive, using both in an appropriate balance to maximize labor efficiency, provide a human scale in the process, and maintain as much as possible a diversity of tasks for workers. At the small end of the scale, the operation can be run by a family with seasonal help at harvest. At the other end, a sizeable outside payroll would be required. The Talbotts' system is ecologically sound, energy-efficient, uses the land intensively, adapts to highly diversified cropping, and they believe, is demonstrably profitable. Transplanting, as opposed to direct field seeding, is the key to Jetspeed.

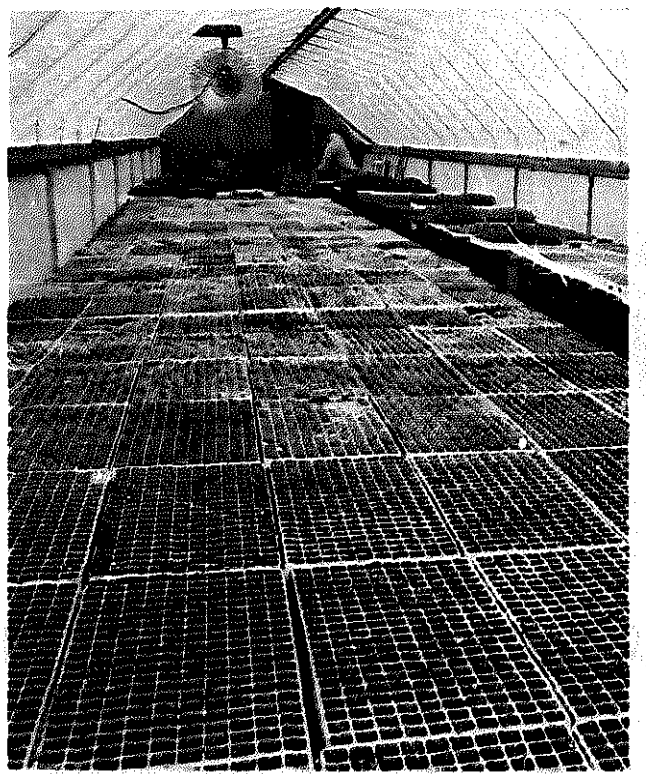
During 1976 and 1977, research and development of all aspects of the Jetspeed transplant row crop system continued at Windfell Farm, some 70 acres located 24 miles west of Portland, Oregon. Windfell was advised that the soil, the slope, and the general conditions were not favorable for row crop production. The acreage had been in grain for years with mediocre results. But the Talbotts accepted the challenge and developed markets for their Biogold products in local communities and the city of Portland.



Long, straight rows of evenly spaced seedlings that require no thinning and a minimum of cultivation are the end product of the Hydro-Synchron, the key to the Talbott's planting system.

Some crops have been routinely transplanted by some growers for generations. The process is slow, often back-breaking and always inefficient, resulting in severe plant shock and mortality. Assuming an improved transplanter, the transplant system insures precise plant spacing and thus, maximum field population. Weeding and thinning problems are greatly reduced or even eliminated with good management, and maturity is more uniform so harvesting costs are reduced. The shorter period from transplanting to harvest means a more intensive and cost-effective use of the land. Talbott advises, "The figure on the bottom line is what counts."

To adopt a transplant system required either a reliable source of plants or a facility for producing them. Windfell developed the systems and the specialized equipment necessary to produce hardy plants that grow fast with stocky tops and strong, branching root systems. Their double-poly house is particularly well adapted to these techniques.



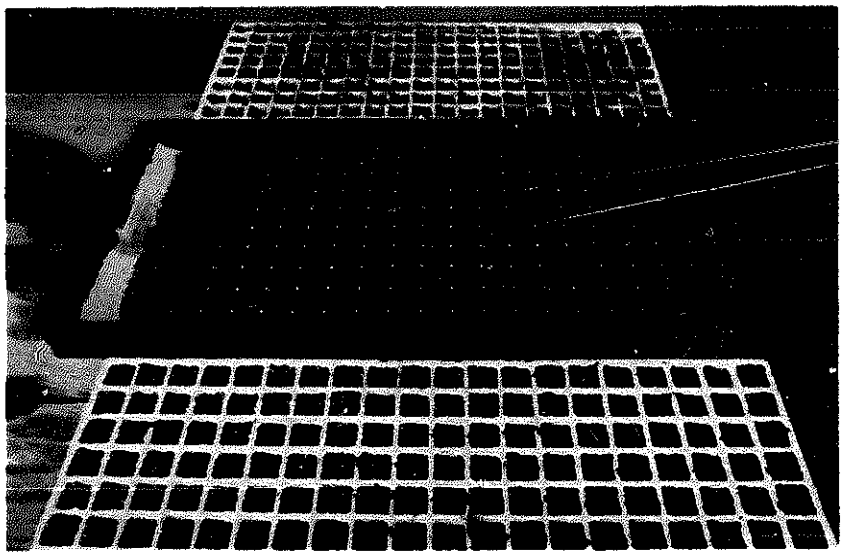
Thousands of seedlings get a good start and grow into hardy plants inside the Talbott double-poly house.



TODD Planter Flats with pyramid-shaped cells.

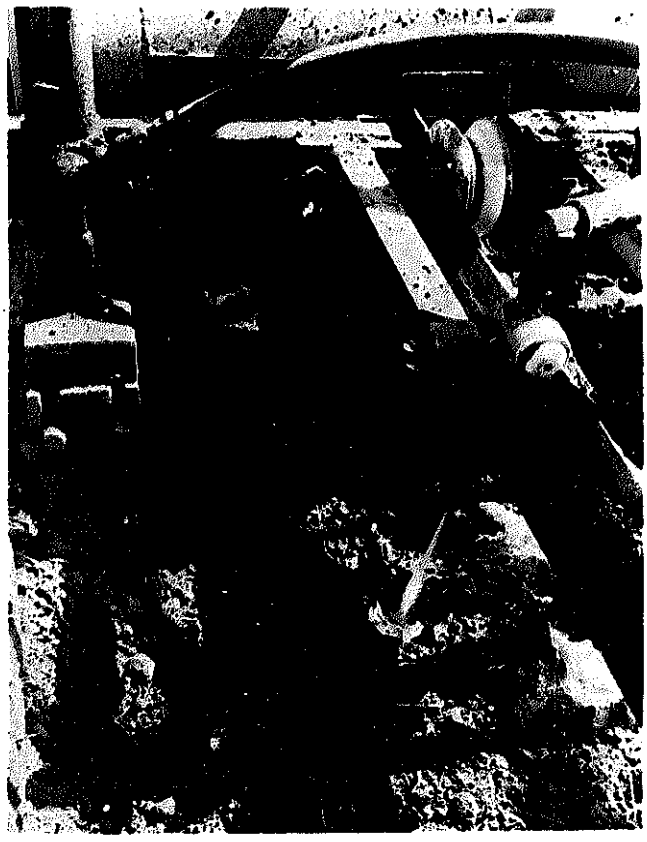
After investigating many different plant-growing systems, it was clear that the Speedling System was the one to adopt. In this system, the patented TODD Planter Flats with inverted, pyramid-shaped cells rest on aluminum T-rails. This promotes natural air pruning of the root system. The result is rapid branching and concentration of the root structure within the cell. Plants can be transplanted with virtually no shock and without interruption of growth.

The Jetspeed planting mix is composed of 50 percent peat, 50 percent vermiculite, bone meal, lime, dolomite, and several additives that have been found to produce the ideal transplants with strong, stocky tops, and quick-growing, widely branching root systems which can be easily pulled intact from the Speedling trays at an early date. The Talbotts found that for the small operator, mixing and tray filling can be done economically with hand labor and good organization. But they found that seeding without an efficient seeder was very time-consuming and costly. Hence the Digit-200 seeder.



The Digit-200 Plate Seeder
Gene Talbott

An ingenious invention, the Digit-200 seeder is simply a tray which sets on top of the 200-unit, cavity trays and has small holes placed exactly in line with where a seed should be deposited. A pile of seeds is scattered across the tray, one dropping in each hole. Excess seeds are gathered at one end. When the tray is lifted, one seed is left in each tray cavity and a thin layer of vermiculite is spread on top. With the Digit-200 seeder, six 200-unit trays can be planted per minute. Making such efficient



A short, powerful blast of fertilized water is the key to the transplanter. The four synchronized nozzles force water into the soil at designated spots as the tractor-pulled transplanter traverses the field. Through a braking system that allows the spray to remain stationary as the tractor continues its slow pace, the driver of the machine need only keep it on course. No stopping or restarting is necessary. As the holes are created, a new seedling is inserted by one of the riders who sits just behind the jet sprays.

use of hand labor, this simple tool exemplifies the kind of inventive work which is needed to develop an appropriate, intermediate, small-farm technology.

The indispensable key to success with the transplant system of row crop production is the transplanter. Experience illustrates that conventional transplanters were totally inadequate; so the Talbotts developed a completely new machine using the hydraulic jet principle. The result was the Hydro-Synchron, a fast, efficient, multirow implement that uses water jets to drill holes to receive the transplants. The drilled holes instantly fill with mud and water (together with a starter solution if desired), and the roots, hand-placed, are sealed deep in the muddy solution at any desired plant and row spacing. Three workers can transplant six rows of lettuce at the rate of about 8,000 plants per hour; wing units increase the planting capacity threefold.



Boxes of seedlings are placed directly in front of the three seats the riders occupy. Seedlings go from box to soil at a suprisingly unhurried pace considering the tractor maintains a constant crawling speed through the field.

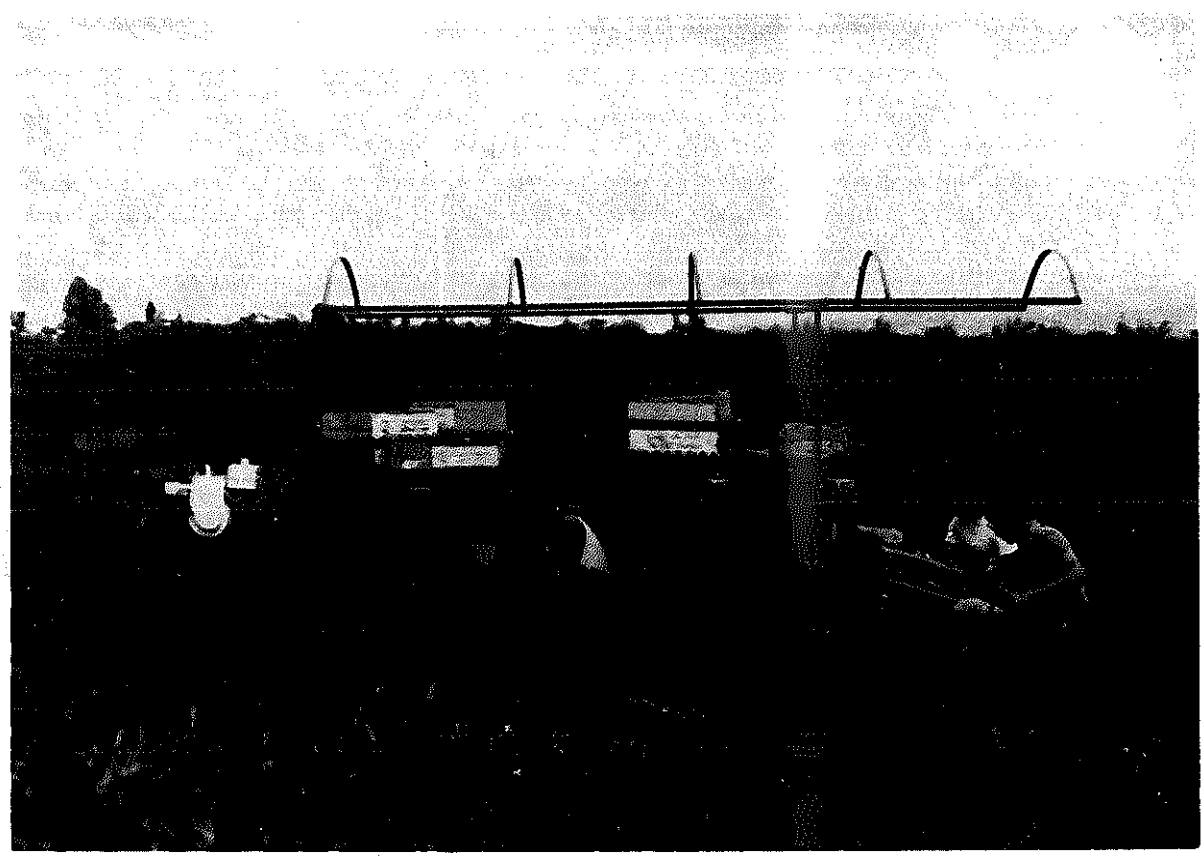
Beyond planting, the Talbotts have other devices and techniques to complete their system. At Windfell, the main implement used in soil preparation is a Rototiller with a corrugated roller pulled in tandem for minimum tillage. Tillage is limited to the upper four inches of the soil. If the organic content of this layer is maintained, the open structure and fertility of the sublayers will be built continuously by a healthy biological population in the soil. Drip irrigation appears to be their only solution to a limited water supply.

Integrated pest control is an area of continuous investigation at Windfell. The availability of compressed air has facilitated experimentation with air-atomizing nozzles attached to the Hydro-Synchron for ultra-low-volume spraying. Numerous test programs are being conducted using some of the recent biological control methods.

For optimum population, the beds are five feet wide, six feet six inches on center and 500 feet long. Population is 2,550 plants per bed, with six rows nine inches apart and plants staggered at 14 inches apart in the row. The spacing is precise and each plant has exactly the same space to grow. It is estimated that with direct-seeded lettuce or celery, uneven spacing cuts the optimum field population by at least 20 percent. Add to this the approximately three-week longer growing period with direct seeding, and the dramatic difference in the two systems is clear.

But experience reveals another important factor with the Jetspeed transplant system—weed control. The rapid establishment of the crop canopy tends to smother weed growth. The beds shown were neither machine cultivated nor hand hoed—and no herbicides were used.

The Walker Harvester, another Talbott development, is a fine implement for assisting in field picking and packing of summer squash, cucumbers, tomatoes, and peppers. The machine is self-



Self-Propelled Walker Harvester
Gene Talbott

propelled and has a hydrostatic drive which is instantly adjustable to any appropriate speed, forward or reverse. A guidance wand keeps the wheels tracking in the spaces between the permanent beds. The two rear wheel cages are adjustable to accommodate various bed widths.

At Windfell, in order to insure a uniform, standard pack, summer squashes are harvested every day, beginning in June and continuing into October. The Jetspeed transplant system brings the crop to market early. Covering the beds with black plastic mulch and transplanting through the plastic will cut another two weeks off the time to market. Other experimental forcing systems are expected to bring the start of harvest even earlier. The grower with the earliest crop can quickly establish his market and command the top preseason prices.

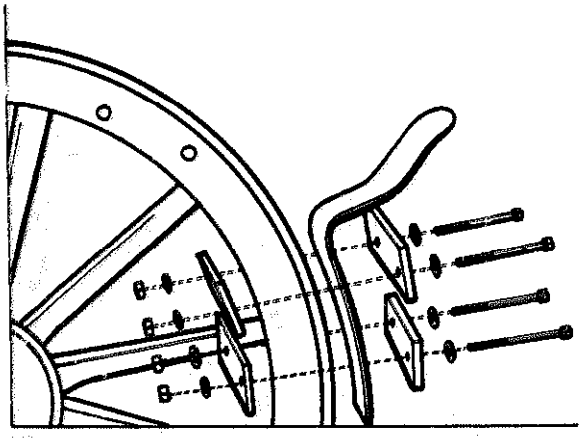
For the small- to medium-sized grower, depending on the local market, diversification can be very important. The Jetspeed transplant system is particularly adaptable to the production of diverse crops side by side. Gross returns from just one lettuce bed were $404 (202-dozen heads at an average price of $2.00 per dozen). One acre consisting of 13 beds grossed $5,252. Under climate conditions at Windfell, a minimum of four and possibly five cycles per season may be obtained. The potential gross per acre is substantial!!

E.V. Prentice Machinery Co.
2303 N. Randolph Ave.
Portland, OR 97227

TRANSPLANTERS

Many crops are traditionally planted as small plants rather than from seed, either to extend the growing season by starting plants indoors, to avoid thinning, or to get more crops planted in one year. The Japanese have developed perhaps the most energy-efficient transplanting mechanism, which they use largely for rice and tobacco. It is a two-wheel tractor with an automatic steering mechanism which guides the tractor while one man feeds plants into the transplanting mechanism.

We in North America are familiar only with tractor-drawn units. They can plant from one to 16 or more rows at a time, with one or two people feeding the transplanter per row. Often, a water tank is mounted on the hauling tractor, and plants are watered with either a continuous or intermittent flow as soon as they are set and firmed into the ground. One unit just described makes the planting hole with a water spray. Additional equipment might include cultivators or a fertilizer distributor.



Here is a hint from **Farm Labor Savers** *suggesting that an extended cleat attached to a wagon wheel be driven across the field to automatically dig evenly spaced planting holes. Used in either wet or dry weather, it will save time and energy when a considerable number of plants or trees are being planted.*

A Semiautomatic Device For Planting Cassava Stem Cuttings on Ridges

From the Agricultural Engineering Department at Ife, Nigeria, G.A. Makanjuola reports the development of a mechanical device for planting cassava stem cuttings on freshly made ridges.

This device is a machine consisting of a disc ridge and semiautomatic planter which can be built as a multirow unit. It can be manufactured entirely locally (Nigeria) with the exception of the ridger discs and bearings.



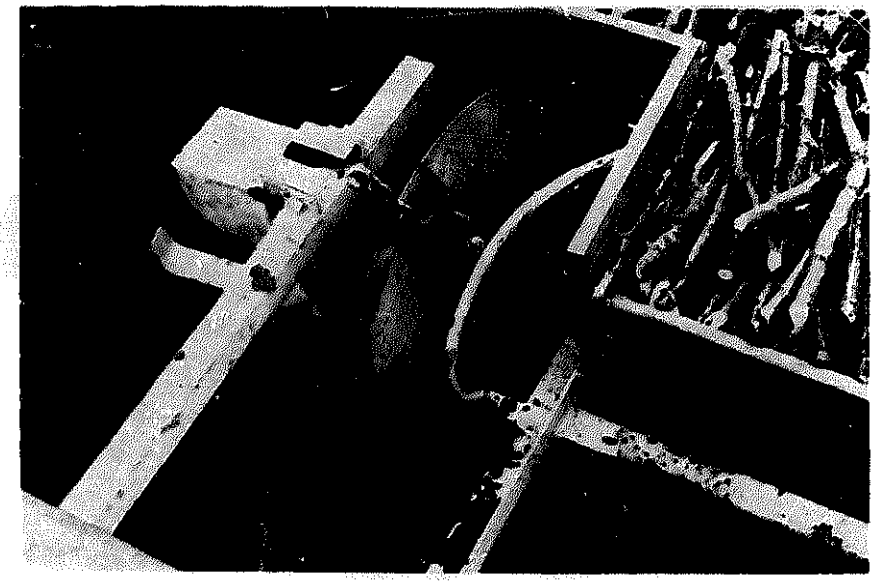
A two-row ridger in operation, pulling a planter behind it with a pipe joint.

Investigations revealed that cassava stem cuttings can be successfully planted on an unridged field with the New Holland transplanter, but it cannot be easily modified to plant on ridges.

The newly designed planting mechanism consists of a disc on which are mounted three rubber pieces cut from 75-millimeter, flat belting material. These rubber pieces serve as hands for holding the stem cuttings in position as the cuttings are pushed into the newly made ridge.

When cuttings reach the erect position they are released. The hands are kept closed by means of a roller which moves along the surface of a curved member. The cuttings are prevented from slipping during the planting process by a combination of the grip of the rubber hands and stops welded toward the center against which the top of the cuttings bear as they are pushed into the soil.

The planter is pulled behind the disc plow and planting discs are mounted on shafts which are driven by chains directly from the implement land wheels. The sprocket on each of the land wheels is mounted on a sleeve which is bolted to the wheel hub. The sprockets on the planting disc shafts are mounted on a hub provided with a pawl and ratchet device which allows power transmission in one direction only. This is to



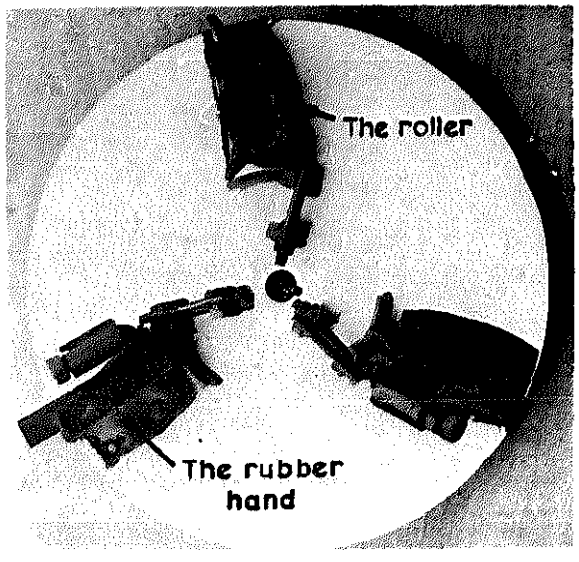
The planting mechanism in operation.

make reversing possible. By varying the number of teeth on both sprockets, it is possible to alter the spacing along the rows. By moving the planting discs along their shafts and adjusting the center distance of the land wheels, it is possible to obtain different spacings between two adjacent rows.

Ellis Transplanters

Deluxe models are available with positive gauge wheel drive. The operators place the plant at the right depth while the machine sets the plant in the furrow, waters the roots, and packs the soil around the roots and stem. Models are available with a one- to four-row capacity.

A continuous or intermittent water supply is available with all Ellis Automatic Transplanters. The system uses two valves mounted on the seat bar between the operators. One valve is used to adjust the amount of water applied per plant while the other shuts the water



The planting disc.

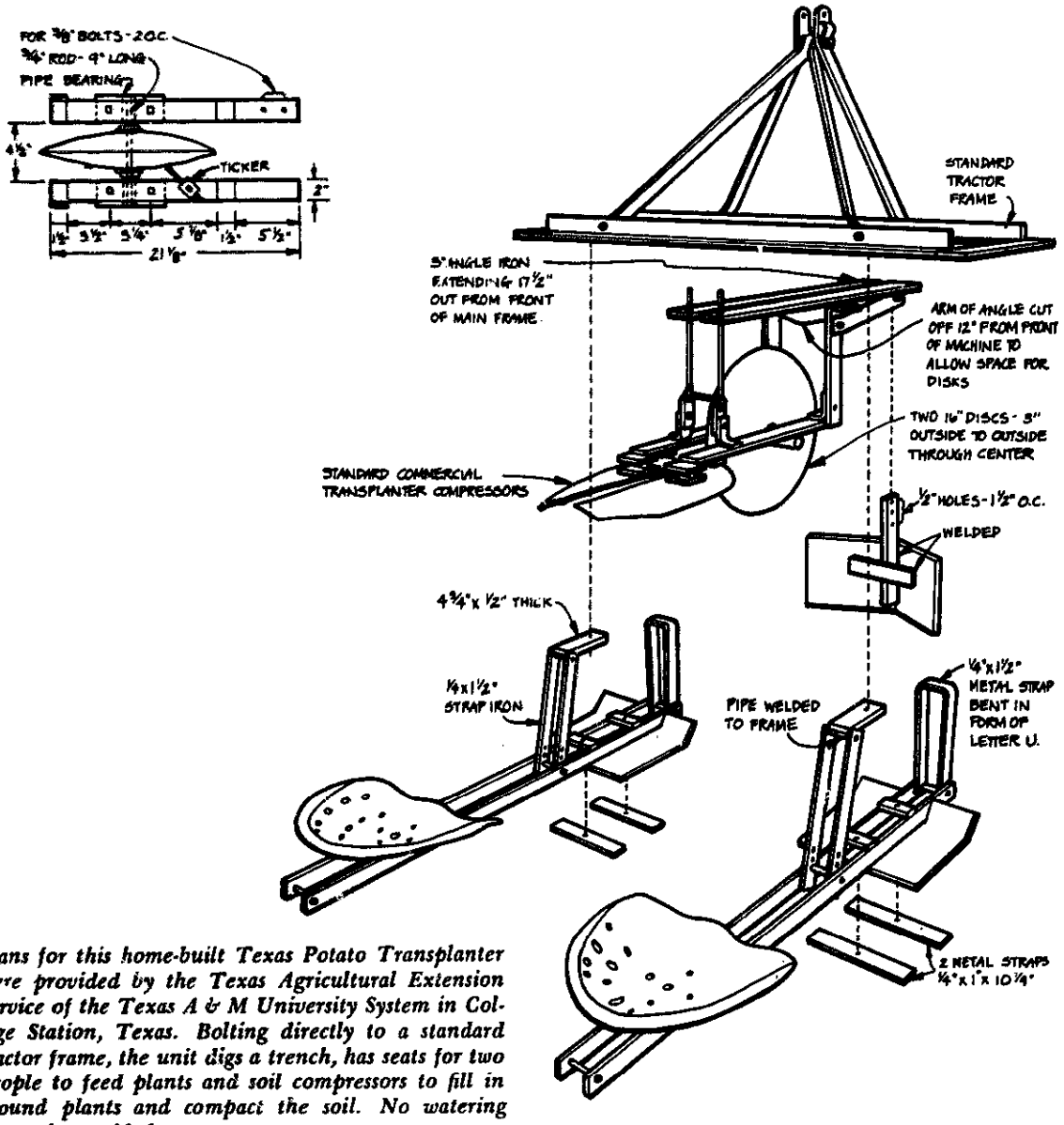
off at the end of a row and on at the beginning of the next.

D.R. Ellis Mfg. Co., Inc.
Box 246
Verona, WI 53593

Mechanical Transplanters

The Mechanical Transplanter Company has a number of models ranging in size from a one-row to a four-row unit which can be attached to any tractor drawbar with a single pin. Everything is adjustable on these units, including seats, footrests, plant spacers, and water valves. The Flo Check watering system turns water on and off at the instant of setting. Water is not lost between plants and the amount of water given each plant can be set by a wing nut adjustment control.

Mechanical Transplanter Co.
S. Central at U.S. 31
Holland, MI 49423



Plans for this home-built Texas Potato Transplanter were provided by the Texas Agricultural Extension Service of the Texas A & M University System in College Station, Texas. Bolting directly to a standard tractor frame, the unit digs a trench, has seats for two people to feed plants and soil compressors to fill in around plants and compact the soil. No watering system is provided.

Holland Transplanters

All Holland Transplanters have adjustable packing wheels, a Start-rite water valve, blunt- or round-point digging shoes, plant stands and plant boxes, plant holders, and back-rested seats as standard equipment. Available units range in size from a special one-row, one-seater unit for garden tractors, to eight-seated, four-row planters. They are available as either tractor-mounted or tractor-drawn units with or without watering tanks, cultivators, and fertilizer distributors.

Holland Transplanter Co.
Holland, MI 49423

Kennco Plant Setters

Available in one-, two-, or three-row models, the Kennco plant setter passes over a completed bed (with or without plastic covering), punches a hole for a plant and a stake (if required), then waters the hole completely, and allows a riding attendant to place a hothouse seedling or seedbed-grown plant directly into the watered hole. Attendants ride at a comfortable position with all plants and controls directly available for rapid but thorough plant setting in each row. Experience has shown that using this method, replanting due to young plant attrition is extremely minimal. Watering controls consist of metering valves and on-off valves handled by the attendant.

Kennco Mfg. Co.
P.O. Box 1158
Ruskin, FL 33570

NORTH AMERICAN SOURCES OF TRANSPLANTERS

Prentice Multirow Transplanter: Hydro-Synchron by Jetspeed

Just described in the article on Windfell Farm, the Jetspeed also has the diversity to convert from transplanter to boom sprayer to cultivator. The machine can plant from one to 18 rows, and the rows can be spaced as desired from 2 to 60 inches apart (with wing units). An attachment is available for planting through black plastic mulch.

A smaller unit, the Jetmaster, is a hand-pushed transplanter designed for planting two 3-foot beds at a time, at any desired spacing, with the same water-jet planting mechanism. Speedling transplants are set by hand by workers following the unit. A whole line of intermediately scaled tools and machinery is designed for a permanent-bed row-crop system.

E.V. Prentice Machinery Co.
2303 N. Randolph Ave.
Portland, OR 97227

Ellis Model 450

This is a one-row transplanter with three-point hitch and a 55-gallon barrel which mounts directly over the hitch and makes it easy to lift. The unit can be attached to some tractors without a three-point hitch, by mounting the barrel on the tractor. These tractors include the John Deere M and MT, the International C, Super A, Cub, and 140, and the Allis-Chalmers CA, D10, D12, and WD. The one-row unit will plant up to 5,000 plants per hour.

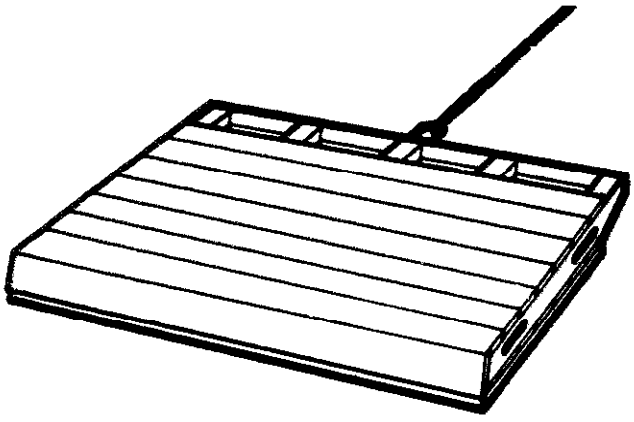
D.R. Ellis Mfg. Co., Inc.
Box 246
Verona, WI 53593

INTERNATIONAL SOURCES OF TRANSPLANTERS

Animal-Drawn Rice Transplanter Platform Plans

This transplanter consists of a wooden platform pulled by a buffalo or a pair of bullocks over the mud of the paddy field when it's ready for transplanting. Four workers are seated cross-legged on the platform, holding the seedlings in their laps. Special recesses are provided on the platform for extra seedlings. Under the platform are attached eight wooden markers, and each worker transplants two of the rows marked in the mud. The workers do not wade through mud and there is no back-breaking bending over. Transplanting is done in parallel rows, at least at twice the normal speed, as both hands are used simultaneously.

Intermediate Technology Publications, Ltd.
9 King St.
London WC2E 8HN, England



Animal-drawn rice transplanter platform.

Rau-Kombi Semiautomatic Potato Planter

This is available as a two- or four-row unit, one operator per row, tractor-drawn implement. It has spring-loaded adjustable covering discs, with a 50-kilogram capacity per hopper. Optional features include a track eliminator, sand plates for driving lugs, a coulter in front of the planting share, and an insecticide applicator. Weight: two-row, 242 kilograms; four-row, 463 kilograms.

Rau-Kombi Planter

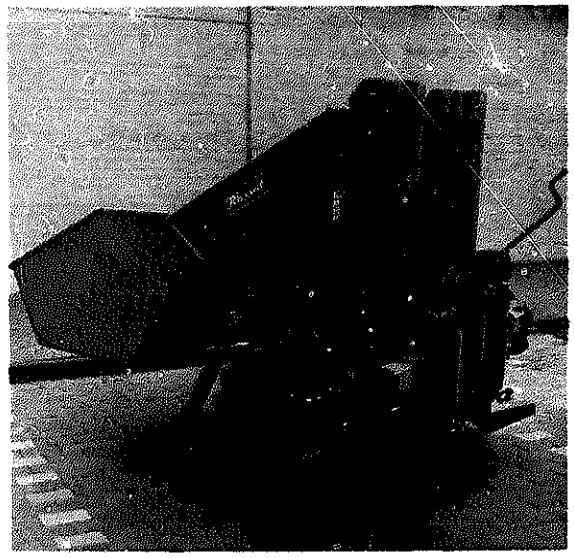
This unit is suitable for vegetables, beets, tobacco, onions, strawberries, forestry plantings, and others. The press rollers do not act above the neck but below, at the feeder roots, closing the soil as required. It will plant two, three, five, or seven rows; spacing of plants along the rows is adjustable.

Hassia-Rau-Vertriebsgesellschaft
D 7315 Weilheim/Tech
Johannes-Rau-Strasse, West Germany

Hassia Automatic Potato Planter

The Hassia potato planter Model GLO is available for planting two and three rows at one time, with row spacing adjustable from 62.5 to 75 centimeters.

A.J. Troster Landmaschinenfabrik
6308 Butzbach, Oberhess
Postfach 240, West Germany



Hassia Automatic Potato Planter.
Hassia

Gruse Potato Planter

This planter has independent, front-mounted furrow openers that are adjustable for depth and float independently to facilitate an even planting depth. Two-row models will plant row widths of between 28 and 36 inches at a maximum speed of 5 mph. It is totally automatic.

RH Group Root Harvesters, Ltd.
Rengate
Peterborough PE1 5BD, England

Nardi Transplanter

This model automatically opens the furrow, places the plant, and firms the soil around it. A synchronized valve on the frame is operated by the planting disc wheel which measures the required amount of water for each plant. On request, the transplanter can be supplied with a fertilizing unit for surface spreading or depositing at a depth of 4 to 6 centimeters below the surface. Transplanting depth is adjustable, and the distance between plants can be adjusted by changing the gears on the drive wheels, changing the diameter of the drive wheels, or by changing the number of pincers. The unit is attached by a three-point hitch and is available with a special attachment for planting in offset rows.

Nardi Macchine Agricole
06017 Selci Lama
Perugia, Italy

Self-Propelled Tobacco Transplanter KC-6

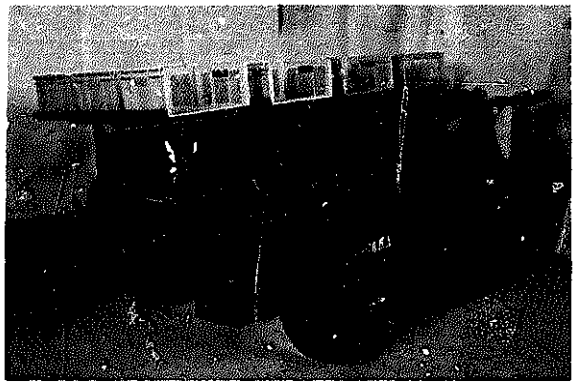
Powered by a four-cycle, air-cooled, 2.3 h.p. engine, this two-wheeled walking transplanter plants all kinds of ridges and furrows—wide, narrow, high, or low—with tobacco plants at spacing intervals from 25 to 45 centimeters in circular or square holes. It can make sharp turns, so no additional turning space is needed. It requires a minimum labor input of one or two people for planting at a rate of 3 to 4 acres per day. The transplanter is self-propelled, with two speeds forward and one reverse. It has automatic steering; it will plant either before or after mulching with a nylon sheet.



Circle Tekko Self-Propelled Tobacco Transplanter KC-6
Circle Tekko Co.

Beet Transplanter BTP-2

The BTP-2 is used with a 35 h.p. tractor with a three-point hitch to plant two furrows at one time at a rate of 1.5 to 2 hectares per day. Its operation utilizes four or five people. Row spacing is adjustable between 550 and 700 millimeters; the planting interval is set at 225 millimeters. Standard attachments include two seedling pot separators, one seedling collector set, 30 seedling boxes, and one set of tools. The BTP-2 uses a new feeding-planting mechanism which guarantees reliable planting and easy adjustment. It comes with a special attachment for planting high furrows. A four-row unit to be pulled behind a 60 h.p. tractor is also available.



Circle Tekko Beet Transplanter BTP-2
Circle Tekko Co.

Both of the above transplanters are available from:

Circle Tekko Co., Ltd.
194 Izumicho, Takikawa-City
Hokkaido, Japan

Metamora Rice Planter MSP-2A

The MSP-2A plants rice seedlings that have developed from two to five true leaves. Seedlings may be raised in mats. A lever can be set for small (2 to 2.5 true leaves), medium (3 to 3.5) and large (4 to 5) seedlings, and also for the number of seedlings in each clump. The lever setting for planting intervals is adjustable in 1-centimeter steps between 12 and 21 centimeters. The seedling feeder is to the rear of the wheels, so that the operator has a good front view. Additional seedlings are set on two trays stacked on top. The trays can be reached from the operating position. Wheels are independently suspended so that the body is maintained in a horizontal position by operating the lever within easy reach. Two-wheel drive and a float for buoyancy assure easy travel across the paddy. Sharp turns can be made by operating side clutches which disengage one wheel as the other keeps moving. Seedlings are not injured by this planting. Planting depth can be varied by adjusting the float. The four-cycle, air-cooled, 3.5 h.p. engine operates the 83-kilogram unit at a capacity of ½ acre per hour as the operator walks along behind. Planting two rows at one time, 30 centimeters apart in clumps of three to five seedlings each, yields a density of from 50 to 90 clumps per 3.3 square meters.

Metamora Tobacco Transplanter

The operator walks behind the machine, feeding the planting mechanism with seedlings less than 22 centimeters high while steering. It will plant tobacco, cabbage, and Chinese cabbage. Adjustments you can make include the distance between seedlings from 25 to 41 centimeters (10 stages), the height of the ridge from 0 to 40 centimeters, the distance between wheels, and the inclination of the chassis. The air-cooled, four-cycle, 2.5 to 3.5 h.p. gasoline engine powers two forward and one reverse speed for planting at a rate of 1 acre every 3 or 4 hours.

Metamora Agricultural Machinery Co., Ltd.
9-37 Nishi 2-Chome
Okegawa, Saitama, Japan

Mizuho Suzue Rice-Transplanting Machine

The Mizuho plants two rows of either young or adult seedlings at a rate of approximately 2½ acres per hour without damage to the plant. Spacing is adjustable between plants, but row width is set at 300 millimeters. One person operates this gasoline-powered machine. A low center of gravity and the well-going straight faculty minimize the amount of attention the unit requires by the driver.

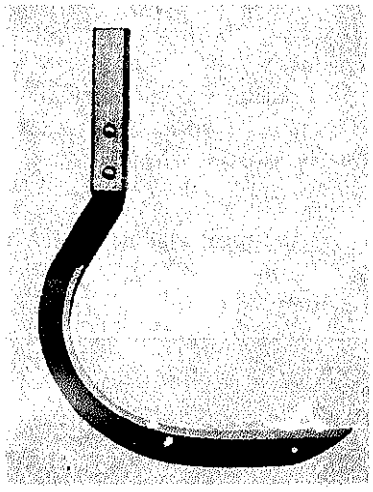
CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

-6- Harvesting Equipment

SICKLE, SCYTHE AND GRAIN CRADLE

The sickle and the scythe are the earliest forms of hand tools developed for harvesting a crop. Although their development can be traced back to around 2,000 B.C., they are still used in many parts of the world today for small-scale farming.

The scythe was developed from the sickle by lengthening the blade and adapting the handle in such a way that both hands of the operator can be used. The larger blade of the scythe increases the rate of doing work, while the longer handle is less fatiguing for the operator as he can stand upright when working. The scythe can be used for harvesting both cereal and forage crops.



A common sickle. True Temper

BRING ON THE SCYTHE

by Drew Langsner

On a year-long trip, we found scythes in common use throughout Europe—from Turkey to France to Scandinavia. In modern Switzerland, Alpine farmers regularly scythe hay on slopes that are too steep for any machinery. Grazing cattle would lead to erosion. And if the grass is allowed to grow, winter snow clings to the long, dry blades until great weights accumulate, causing avalanches and loss of precious soil.

The Alpine farmers are very practical workers, so I was particularly interested in their technique for mowing. Watching a man and his teenage sons scything a very steep field gave me the impression of a functional ballet. The effort exerted was great, yet light and rhythmic all at once. About every 15 minutes work halted. The blades were quickly honed with a whetstone kept in a water-filled scabbard hung from each man's belt. With razor-sharp blades, mowing resumed until a small field, perhaps an acre, was cut.

One day our Swiss host informed me that the grass around his cheese-making hut was of sufficient growth for mowing into a small amount of fodder. Of course, I was quite anxious to try scything.

First he demonstrated his sharpening procedure. The edge of the blade must be so thin that it deflects when pressed against one's thumbnail. Lightweight grass-cutting blades come this way new. But after repeated honings, the thin edge section wears away, leaving a cutting edge too thick for razor-edge sharpening. Rethinning is done by pounding the blade with a hammer over a small stake anvil driven into a log. When the blade passes the thumbnail test, it is ready for honing.

That job is accomplished with the long, thin whetstone. The stroke used is very similar to knife sharpening—the stone is worked toward the edge with long, smooth passes at a very slight angle. The stone is dipped in water every minute or so to wash away accumulating grit that would contaminate its pores and hinder further sharpening. The test of an adequately sharp blade is in its



To begin a stroke, your trunk is twisted quite far to the right.

use. One should feel almost zero friction between the blade and the grass being cut.

For the proper mowing technique, legs are set rather apart, knees are bent a little, and the body cants forward at a slight angle for balance.

To begin a stroke, your trunk is twisted quite far to the right. The scythe is held so that the tang, the shank connecting the blade and handle, is just above the ground, at cutting depth. The blade tip is angled slightly upwards, but not much. The position of the tang regulates the cut. The slightly lifted tip is to help avoid hitting obstructions during the stroke. Finally, the blade is aimed so that it will cut a very thin swath with each stroke. The scythe is not a hacking weed chopper, but a fine cutting tool. In use, the blade actually slices along whatever is being cut. Each pass mows only a few inches in depth, perhaps six to ten inches, depending on the blade length.

The actual stroke involves using your entire body in a smooth, pivoting movement. Beginning at the right, swing in a full arc until your shoulders are turned all the way left. (This long, thin stroke actually cuts more grass than a short, broad hacking movement.) Then take a short step forward as the scythe is returned to the beginning position.

To mow a patch of grass, grain, or weeds, begin at the left edge and gradually work your way from one end to another. You can work up or downhill, but always go in the same direction. After mowing one swath, return to the beginning edge and mow a second swath one arc space to



The actual stroke involves the entire body in a smooth, pivoting movement.

the right. Working in this fashion, your reapings will fall away to the cut side, not against standing growth in the following swath.

Several types of scythe blades and snaths (handles) are currently available in America. The standard blade, 30 inches long and made of fairly heavy steel, is suitable for cutting weeds and small grains. A shorter, even stouter blade is sold for clearing brush and briars.

The technique for using these scythes is the same as for mowing grass, but with extra vigor. These blades are generally not pounded thin or sharpened to such a high degree as grass blades. But they must be kept quite sharp to be effective. Standard blades are generally sharpened with a mill file or on a hand-turned grindstone. Work mainly on the bottom side of the edge. Many a frustrated mower has a blade sharpened on the upper edge. This creates a downward-slanting bevel that tends to run the scythe into the ground as it cuts. Always sharpen standard blades on the lower side first, then gently remove any wire edge that may form on the upper side. It is a good idea to finish up by honing with a hand stone.

Recently, thin, lightweight grass blades have been imported to this country. These blades are excellent for fine mowing work, but they are not suitable for cutting tough weeds. They are delicate; the fine edge is quickly dulled or nicked if run into the ground, a stone, or hidden debris.

Two styles of snaths, or handles, are on the market. The standard snath is made of bent ash

and is quite heavy. These are rugged and suitable for use with standard and brush blades. Also available is a bent aluminum snath, which works quite well with the superlight grass blade. But aluminum snaths are too light for the more rugged work of cutting grain, coarse weeds, or briars. For such tasks, the extra weight of the ash snath creates a momentum that helps in mowing. Wooden snaths should be cleaned and treated, once or twice a year, with a mixture of two parts linseed oil to one part turpentine.

Some older hardware stores still carry scythes, especially in country districts. You might have to ask, as the last one ever ordered may be in the back storeroom.

Often scythes appear at auctions or yard sales. It is not too hard to clean up a mildly rusted blade. Be sure that the snath is not cracked, and that it has one, or preferably two, handles. (Snath handles are tightened by twisting counterclockwise.)

GRAIN CRADLE

The grain cradle is an improved scythe with a set of wooden tines above the blade that catch the wheat (or other grains) as the blade severs it on the forward swing. Mastering the art of the scythe and grain cradle takes coordination and practice. For a right-handed stroke, the left foot is placed one stride forward and the first stroke is taken with the blade nearly parallel to the ground. The trick is to keep the grain stalks laying all one way during the next four strokes. Before each consecutive stroke, the right foot comes forward one-quarter stride. After the fourth stride, the wheat on the tines is slid off into a neat pile at the farther reach of the cradle's forward swing, ready to be tied into a bundle.

A farmer is a proud person: proud of his tools and proud of the work he and his tools produce when working as one, together. And with good reason; it takes practice and skill to master a task. Like an old pair of shoes, the tool conforms to the technique its master employs—becomes molded to his style and uncomfortable in the hands of another. The skill and intimacy in the relationship between man and tool are reflected in the following article by Steve Taylor about mowing with a scythe and the rare people who have the skill to use it right.



Harvesting grain by hand with the help of the scythe and grain cradle. United States Department of Agriculture

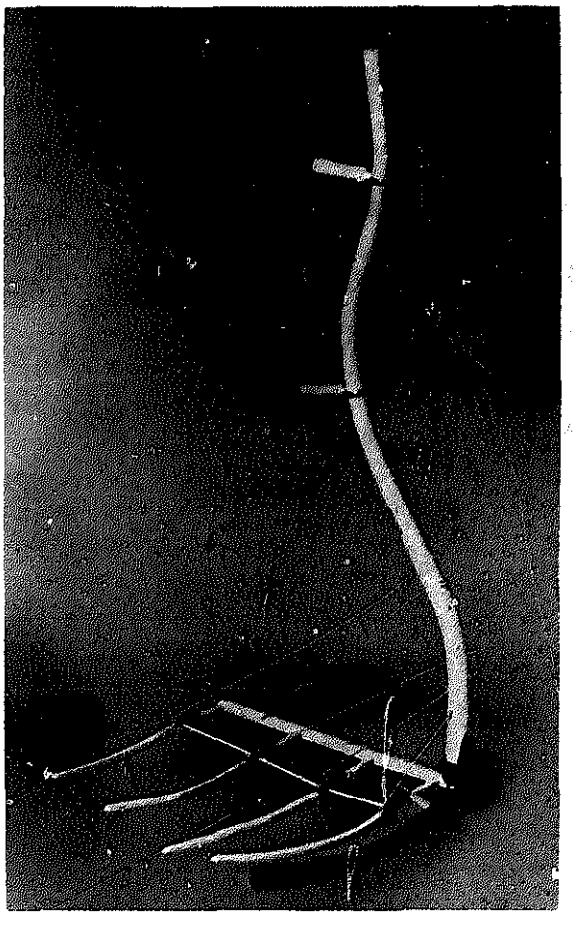
BUILD-IT-YOURSELF GRAIN CRADLE

by Richard Weinsteiger

With new grain cradles impossible to find, and old cradles expensive and rare, here is an inexpensive way to convert a grass scythe into a functional cradle.

CONSTRUCTION

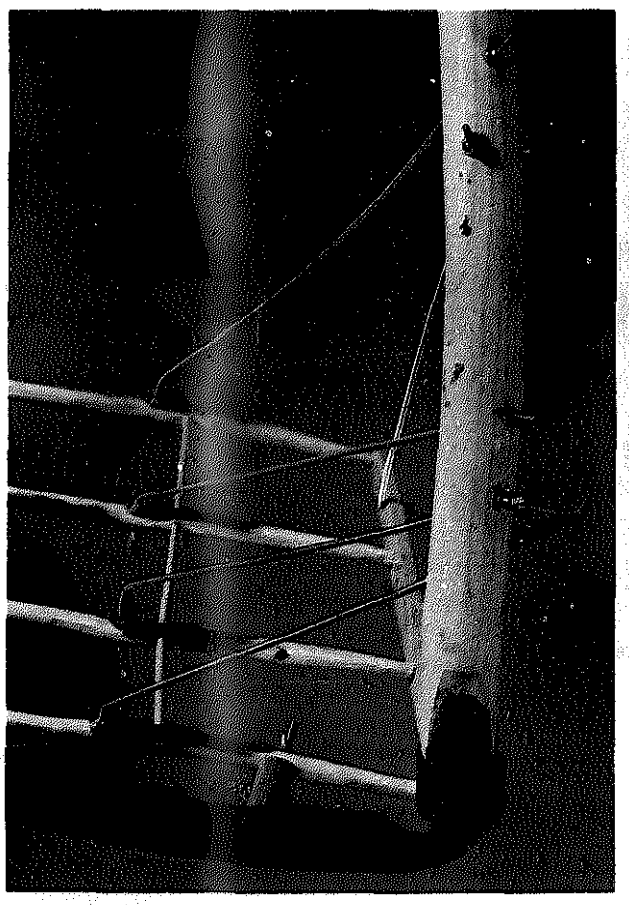
1. Start by obtaining a 30-inch-length by 3-inch-diameter piece of knot-free green hickory or ash. Remove the bark, using a drawknife and quarter the log. Shape the four pieces with the drawknife until they are approximately ¾ by ⅝ inches. Then, starting 10 inches from one end, taper the remainder to ⅜-inch diameter.
2. In order to bend these pieces to conform to the shape of the scythe blade, a jig has to be built using a 27-inch scrap piece of 2 x 4 and four pieces of 6-by-¾-inch dowel. Since all blades do not have the same arc, you will have to position the dowels accordingly. After the jig is built, place the four pieces in the jig and let dry for several days.
3. The upright or main support piece, also made from hardwood, is ⅝ by 1⅛ by 23½ inches. Drill four ⅜-inch holes 2, 8, 15 and 23 inches from the bottom. A shallow groove is filed across the grain ¾ inch from the bottom to accommodate the J-bolt. Drill a ¼-inch hole in the front face of the metal end cap of the scythe handle for the J-bolt. Make sure the hole is far enough from the center to avoid the blade clamp bolt.
4. Remove the pieces from the jig, apply resin to all outside bends and char with a torch to set

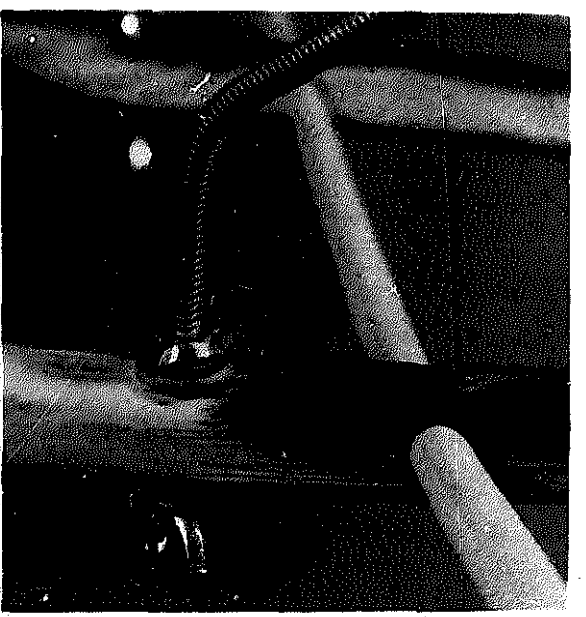


A grain cradle can be built to fit any store-bought scythe

the bends. Then whittle 5/8 inch of the ends that are to fit into the upright to a 3/8-inch diameter. Drill a 3/8-inch hole vertically 7½ inches from the support end for a supporting dowel to slide through, and in each piece a 3/16-inch diameter hole horizontally 9 inches from the end for the supporting all-thread.

5. Now assemble the unit by inserting the J-bolt with the upright attached to the faceplate and tightening the nut. Insert the four bent pieces into the holes in the upright. Place the 5/16-inch-diameter by 23¼-inch dowel through the vertical holes of the bent pieces. Next, drill a 3/16-inch hole midway between the top two bent arms. Cut a 26-inch piece of 3/16-inch all-thread, and make a right-angle bend 1½ inches from one end. Insert this piece with the right-angle bend into the 3/16-inch hole at the top of the upright, and fasten with a washer and wing nut. Judging the angle by holding the piece of all-thread to intersect the handle, drill a 3/16-inch hole 16 inches from the end cap. Cut four pieces of all-thread 28½, 22, 17 and 14½ inches in length, and using the same method, attach to the handle 17½, 10, 8 and 7 inches respectively. Put wing nuts on both the inside and outside of the pieces that are inserted in the bent arms.
6. Cut a 2-inch piece of ¾-inch dowel, and drill a 3/16-inch hole through the center lengthwise. The same diameter hole should be drilled in the bottom bent arm and the blade approximately 4½ inches from the handle. Cut a 4-inch length of 3/16-inch all-thread, and peen one end so that it will not slip through the hole in the blade. Insert through the blade, dowel and arm, and fasten with washer and a wing nut. Using ¾-inch brads, fasten the dowels to the arms and upright. Then adjust the wing nuts on the arms and handle to align the arms with the blade, making sure to keep the arms in back of the blade edge.





The supporting all-thread strut is bolted in place with a wing nut.

The cradle's simple supportive network is adequately braced.

HAND MOWING: FEW HAVE THE SKILL TO SWING A SCYTHE—PROPERLY*

Story by Steve Taylor, Photos by Bob LaPree

Elwin Smith, herdsman on a large, East Washington dairy farm, gripped the handle of his scythe and at the starter's command went forth to mow the prescribed 50-foot course. Judges hovered around, measuring the swath he lay down in the lush green grass and clover.

When a half-dozen others had had their turn and the points and times were added up, Smith had won the Golden Scythe Award, symbolic of supremacy in the art of hand mowing in Sullivan County and other points east of the Mississippi.

The Sullivan County Dairy Herd Improvement Association (DHIA) has held its hand mowing championship every summer for the past 25 years or so. Anybody who thinks he or she is up to it can take a crack at winning a new scythe decorated with gold spray paint.



Elwin Smith, winner of the Golden Scythe Award. Neatness of stubble nudged him ahead of the others. Bob LaPree

* Reprinted with permission from *New Hampshire Times*, 27 July 1977.

Elwin Smith calls himself an old-timer, and it's usually old-timers who win the Sullivan County DHIA's Golden Scythe. In 1977, Smith nudged out three dairy farmers by one- to three-tenths of a point, and all were veterans in the scythe competition. They were Fred Hall of West Unit, defending champ Horace Bascom of Charlestown, and Smith's boss, Hans Eccardt of East Washington.

A broiling July sun beat down on Charlie Stone's beautiful Meriden dairy farm, and the temperature hovered at 99 degrees in the meadow across the road from the cow barn. The veteran scythemen warmed up by taking a few swings at grass around the edges of the field and then set to work putting fine edges on their scythes with pocket-size sharpening stones. Then one by one they mowed the course.

The competition is scored on a combination of factors. Time over course is worth 15 points, width of cut 30 points, neatness of stubble 45 points, and completing course 10 points. Penalty points up to 10 can be assessed by the judges for spitting tobacco juice on the course or giving judges or bystanders lip.



Judges measure the width of his swath as Hans Eccardt finishes his course.
Bob LaPree

Elwin Smith was slower on the course, achieving 11 out of a possible 15 points. He ran well behind speed merchant Horace Bascom, who laid down his swath in two minutes, five seconds. But Smith picked up a total of 43 out of 45 possible points for neatness of stubble and that gave him the victory.

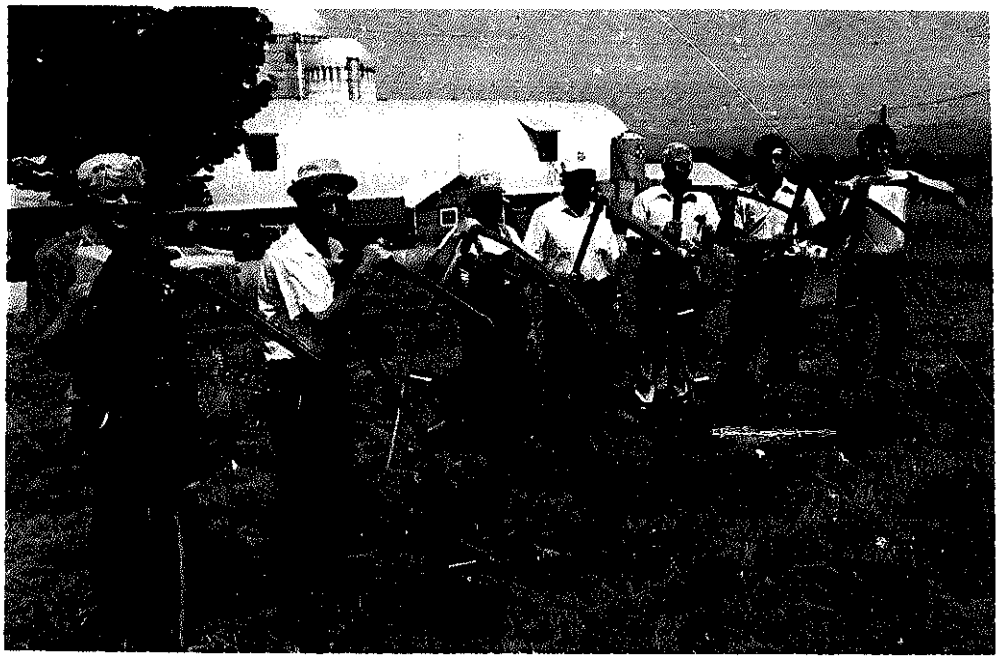
The swath where Smith had mowed looked like it had been cut with a lawnmower, so short was the remaining growth, and there weren't many places where the scythe had skipped and left little telltale manes of uncut grass.

Smith was repeating what he'd done at the DHIA field day back in 1959, winning the big prize, and darned if he didn't use the scythe he was given for the '59 championship to win in '77.

Later there was a competition for greenhorns, also known as dubbers or hackers. This was won by a Meriden area farmer-writer whose swath—like those of other contestants in his class—looked like it had been carved up with a hatchet.

After the competition, the veterans stood around and talked about their individual scythes. Eccardt had a European-style model with a straight handle. Stan Colby from Cornish praised his cherry snath. Elwin Smith savored a cold bottle of Miller beer Eccardt had sequestered in a clump of clover by the fence.

Then it was off to a picnic on the Stone farm lawn, with fiddle music by the Dave Levine



The competitors pose for the camera (left to right): Stan Colby, Elwin Smith, Fred Hall, Hans Eccardt, Horace Bascom, Dean Bascom and Bennie Nelson. **Bob LaPree**

orchestra. Another hand mowing competition had been written into history, its participants and spectators well entertained at the sight of the vestiges of an ancient art.

Virtually every boy and man in rural New Hampshire knew how to swing a scythe a century ago. The skill was essential to family and individual survival, for it was the means by which the basic feed of livestock—hay—was harvested on the land.

Hand mowing as a skill exists today, but only among old-timers and a few younger men who probably have learned it working on a highway crew responsible for trimming roadsides.

Hay was harvested in July and August a century ago, and came all in one crop. Today, the first cutting is in the barn before July 4, and second and third cuttings come along later in the summer. That's because of the introduction of legumes such as alfalfa and trefoil, which have displaced timothy and other grasses, the old standbys for hay production in New Hampshire.

During the Civil War, many New Hampshire farm hands enlisted in the Union Army and marched off to fight. A similar development in other northern states stimulated the development of farm machinery to speed up and ease the task of harvesting hay in this area.

The first significant invention was the horse-drawn mowing machine, which was developed in 1847 but not perfected until well after the Civil War. The mechanical hay loader and the dump rake were introduced in the 1870s, and the pace of haying was stepped up considerably.

The need for skilled scythemen diminished steadily in the late nineteenth century, although many poorer farmers continued to put up hay using the old methods. These farmers kept alive the traditional methods and procedures.

Haying with scythe, hand rake, and pitchfork traditionally began on the first Monday after the Fourth of July.

Work began at dawn when several men went out to do barn chores and milking. While chores were being completed, Grandpa and the young boys would go to work on sharpening scythes in preparation for the day's mowing. The kids would have to turn the crank on the grindstone while Grandpa would start water trickling on the stone.

After removing the snath, or handle, from the scythe, Grandpa would grasp the blade in both hands and bear down on the stone. The stone would turn rapidly without resistance, but as the



Stan Colby sharpens his scythe with a whetstone.
Bob LaPree

pressure increased, the stone would slow to a drag. Periodically the edge would be tested with a thumb, and after 10 or 15 minutes the job would probably be done. To a youngster that would seem like an eternity, especially if there were two or three more blades to go.

After sharpening the blades on the grindstone, a whetstone, sometimes called a rifle, would give them an even keener edge.

After breakfast, the crew would assemble in the field and work would begin. The hired men would start off first, followed by Dad or whoever was boss. The boss would try to crowd the mowers ahead of him, and if he passed one or more of them in the advancing echelon, they were disgraced and had to retreat and pick up a new swath at the rear.

Behind the mowers would come young boys with pitchforks, spreading out the newly mown hay to speed up drying. Since hand mowing is such hard physical work, especially if the men were being pushed by weather or the boss to produce, mowing was usually done in the cool of the morning. The afternoon was devoted to raking up, tumbling, and loading the hay onto wagons for transport to the barn.

In raking, the crew would set out in reverse order of the morning arrangement, with the young boys leading with small rakes, and the stronger men bringing up the progressively larger mounds of hay into windrows. While one man fetched the horses and wagon, the others would tumble the hay, that is, arrange it in piles which could be forked directly onto the load and which presumably would stay intact through several handlings from field to mow.

Next would come the time to pitch hay. Strong arms would fork the hay onto the wagon, then fork it off the wagon at the barn, shove it up into the storage area where it would be mowed away. The following winter the hay was supposed to come out of the mow by the tumble as it had gone in, but likely as not, it came out with much grunting and groaning and not by the tumble.

The tremendous physical exertion required that large quantities of fluids be available in the field. Cider was one important beverage; some old accounts tell of rum; switchel is said to have been a popular refreshment. Switchel was a concoction of cold water, sugar, ginger, and vinegar, and those still around who have consumed it say it was more or less thirst quenching.

As late as the 1880s, there were purists who refused to adopt the labor-saving machines such as the mower and dump rake, often claiming the iron wheels spoiled the land. So they kept swinging their scythes. But as time rolled on, there came to be fewer and fewer farms where the hay was harvested by pure human muscle power.

Hand mowing is the same sort of rural skill as sheep shearing. It requires determination as much as anything. It also requires reasonable muscular condition and a fair measure of coordination. But once the essential rhythms and movements are mastered, it can be done with grace and smoothness.

A man who can handle a scythe as gracefully and efficiently as anyone in New Hampshire is Stanley Colby of Cornish, a retired agricultural extension agent for Sullivan County and now a town selectman and amateur historian.

Colby grew up on a river farm in Plainfield. His father declined to do hand mowing when Stanley approached manhood, and so the boy had to learn. Colby's grandfather, Albon Wood, instructed him on mowing by hand with a scythe and coached him for a year or two. Wood could mow all day long and hardly work up a sweat, Colby recalls. Colby is willing to coach greenhorns today, much as his grandfather did him a half century ago.

"There's not much to it. You just have to know how to mow, how to sharpen a scythe, and how to set the nibs." The nibs are the handles affixed to the snath, which is the curved handle of the tool. The scythe is the metal blade which does the actual cutting.

"You should set the nibs so they're comfortable and then hold the tool in a normal position close to your body. The tip of the scythe should then be at your left foot.

"Then you do it. You keep your heel down, stand up tall. If you bend forward, you'll be a basket case in no time," Colby advises.

Good scythes are hard to find these days. The ones made for the market today are typically imported tools. "Those rigs may be okay for Austria or some such place, but they're not much good for anything over here except maybe cleaning around a fence post or something," Colby snorts.

Many scythes on the market now are ill shaped and don't have enough steel to take and hold a good edge, and the handles are generally inferior. Colby likes a snath made of cherry, but it's impossible to find cherry snaths today.

The best method of finding a good scythe is looking around in old barns. A lot of scythes got stuck away up on beams years ago, and not many people have gone seeking them out for use since.

Most of the winners in the Sullivan County hand mowing championship over the years have brought their own pet scythes with them. Horace Bascom, Sid Clarke, Jesse Stone, and Colby have captured the title most of the time, and all of them did it with their own special tools.

Finding a good grindstone on which to set a scythe is difficult, too, Colby says. Most of the good stones have been appropriated by homeowners and antique fanciers for decorations. Once left to weather, old grindstones are worthless for sharpening scythes.

HARVESTING RICE

Rice is harvested in much the same way as other cereal crops. Care must be taken not to shatter the hull and risk losing some of the grain. Combines designed for wheat harvest (described later in this chapter), as well as sickles and knives, may be used for harvesting rice. However, tools designed by CeCoCo in Japan are specifically for rice harvest and are described as follows.

CeCoCo Hand-Pushed Rice Planter-Cutter

This is an adjustable, hand-pushed rice cutter which promises to make the work of men, women, or children five times faster than when using a hand sickle. A 20-inch wide cradle collects the stalks as they are cut.

CeCoCo Hand Rice Plant Cutter

This tool will reap slightly more than 1/10 acre per hour. The blade is easily detached for cleaning and sharpening. The operator uses both arms to power this tool and stands in an almost erect position. This technique is easy on workers and gives them the power to easily cut through stalks, even thick-cropped rice plants, leaving them grouped and ready for sheaves.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

NORTH AMERICAN SOURCES OF HAND HARVESTING TOOLS

	SNATHS	SCYTHES	SICKLES
AMES			X
BELKNAP, INC.	X	X	
COLUMBIAN CUTLERY CO.		X	
COUNTRYSIDE CATALOG	X	X	X
CUMBERLAND GENERAL STORE	X	X	
DEGIORGI CO., INC.	X	X	
GLEN-BEL'S COUNTRY STORE	X	X	
A. M. LEONARD & SON, INC.	X	X	
BEN MEADOWS CO.	X	X	
MOTHER'S GENERAL STORE	X	X	
NASCO AGRICULTURAL SCIENCES	X	X	
NORTHEAST CARRY TRADING CO.	X	X	X
G. E. RUHMANN MFG. CO., INC.			X
SEYMOUR MFG. CO.	X	X	X
STANLEY GARDEN TOOLS—U.S.		X	
TRUE TEMPER CORP.			X
THE UNION FORK & HOE CO.			X

INTERNATIONAL SOURCES OF HAND HARVESTING TOOLS

	SNATHS	SCYTHES	SICKLES
BULLDOG		X	X
CARALEL ENTERPRISE CO., LTD.			X
CEAF S.N.C. F. LLI SILETTI	X		X
ENGLISH TOOLS, LTD.		X	X
FABRICHE RIUNITE FALCI		X	X
FERFOR			X
HINDUSTAN ENGINEERING CO.			X
T. & G. HUTTON & CO., LTD.			X
JENKS & CATELL, LTD.			X
KUMAON AGRI-HORTICULTURE STORES			X
KUMAON NURSERY			X
KUMAR INDUSTRIES			X
LASHER TOOLS (PTY.), LTD.			X
OY RETTIG-STRENGBERG, AB	X		
GEORGE PIKE, LTD.	X		
PURMO PRODUKT	X		
SELF-SUFF. & SMALL-HOLDING SUPPLIES	X	X	
FRANZ SONNLEITHNER K.G.			X
SPEAR & JACKSON TOOLS, LTD.			X
STANLEY GARDEN TOOLS, LTD.		X	
SYNDICAT DE L'OUTILLAGE		X	X
W. TYZACK SONS & TURNER, LTD.		X	X
UBUNGO FARM IMPLEMENTS		X	X

CeCoCo Power Reaper

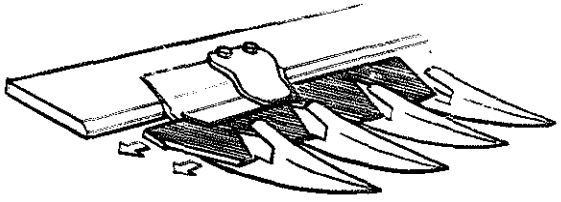
This is a lightweight tool designed to cut wheat or rice stalks at a rate of ¼ acre per hour. It is made of steel pipe and is powered by a 1½ h.p., air-cooled engine.

All three above cutters are made by:
CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Reciprocating Mower-Cutter

The reciprocating mower is a high-speed machine which has largely superceded the scythe for cutting grass and forage crops, even for small acreages. Cutting close to the ground, it is especially valuable for harvesting badly laid cereal crops. Avoiding the chopping and shredding action of forage mowers, reciprocating mowers do not disturb the kernel or separate it from its husk. Left intact, threshing and cleaning procedures can be saved until a convenient time after the crop is safely delivered to the barn.

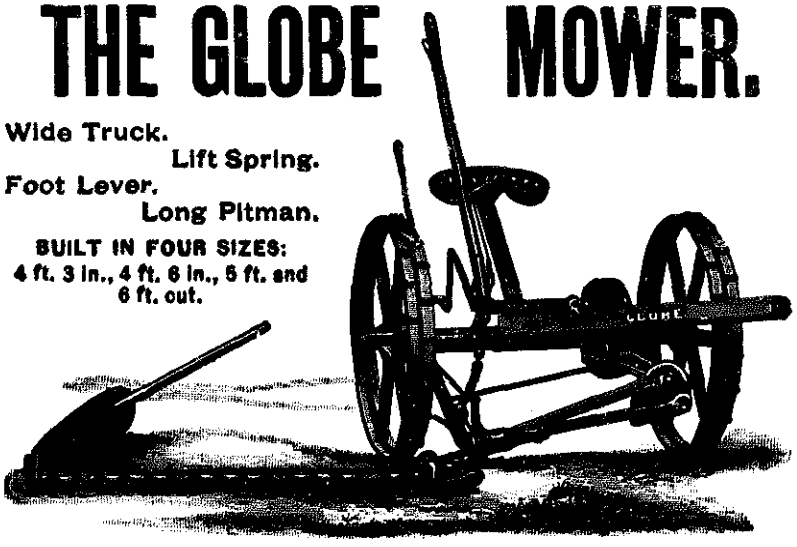
The cutting mechanism of a reciprocating mower consists of a set of triangular-shaped cutting knives operating with a back and forth motion inside a guide shaped like a comb. It



The cutting mechanism of a reciprocating mower.

can be either an animal-drawn or ground-driven machine, have its own power unit (motor mower), or be a front end or side attachment for a two- or four-wheel tractor.

When animal-drawn, the large land wheel rotating on the ground as the animal draws the machine forward provides the power to operate the mower knives through the gearbox and the pitman. For the tractor-drawn types, the power to operate the machine is obtained from the tractor engine. The tractor-drawn mower can be hitched to the tractor in a number of ways.



An animal-drawn, ground-driven mower with mechanical lift. The Implement Age, 1894



a. The mower can be a trailing unit behind the tractor and the power to the reciprocating knives is then provided by the tractor engine through the power take-off (PTO) shaft.
b. The mower can be mounted on the tractor
   1. at the rear of the three-point linkage, and is then driven by the PTO shaft;
   2. at the middle under the main body of the tractor, and is then driven through the tractor belt pulley;
   3. ahead of the front steering wheels, and is then driven through the pulley mounted in front of the tractor engine; or
   4. ahead of the power unit, and is then driven through a power take-off shaft.

The Agria 1800 Tractor with a rear-mounted, side-operating reciprocating mower. The mower mounts on a three-point hitch with hydraulic lift and is powered by a rear PTO shaft.
Agria-Werke

In some recent models, the power to operate the mower knives is provided by the tractor's hydraulic system through a flexible coupling instead of the rather difficult mechanical arrangement of the power take-off shaft and universal joints or V-belts. The location of the hydraulically operated mower in relation to the tractor can be either at the rear, middle, or front, the last two positions allowing the tractor driver to supervise its operation with ease.

The main disadvantages of a reciprocating mower are:

a. the working parts are liable to rapid wear,
b. they are not successful in heavy vegetation, and
c. the ground surface needs to be fairly level for satisfactory operation.

Reciprocating mowers are generally used for light grasses which are grown for hay. The cut grass is left in the field in a thin, orderly row which helps it dry quickly. Some mowers have gathering attachments which direct the stalks to fall into windrows, which simplifies handling afterwards. Turning the grass with a swath turner helps further the drying process. But when harvesting some grains, there is a threat of losing the seed, so the crop is gathered right away and threshed soon after.

It is difficult and perhaps even unnecessary to draw a clear distinction between single-axle tractors and motor mowers because mowing attachments are available for some tractors, and cultivating and trailing equipment is often available for motor mowers. Many of the mowers listed in this chapter can be used for fodder or grain crops such as wheat. Rice, however, is often prone to shattering and is not suited to this type of machine.

A SEED HEAD HARVESTER FOR SMALL PLOTS*

by Rex L. Smith, Ph.D.

Editor's note: The lack of intermediate-scaled mechanization for harvesting small acreages of cereals encouraged us to adapt the following article from *Crop Science* into building instructions for a hand-carried, reciprocating harvester. Author Rex L. Smith originally published his article entitled "A Grass Seed Harvester For Small Plots" because "the seed harvester was helpful to my grass-breeding program and I wanted to share the information."

Seeds from small plots, especially those of species whose hulls shatter easily and whose seeds can be lost in the field, have been harvested mostly by hand because no suitable harvesters have been readily available. The increased cost of labor has made this practice expensive and, in our case, has restricted research because of insufficient seed quantities. The harvester described here was designed and built to reduce the cost and facilitate the seed harvesting of small plots of grass. It can reduce the time and labor requirements of hand cutting to one-fifth. The harvester is versatile and will effectively cut many species, including those producing small grains. In addition to harvesting seed, the cutter will also cut grass and legume forage samples.

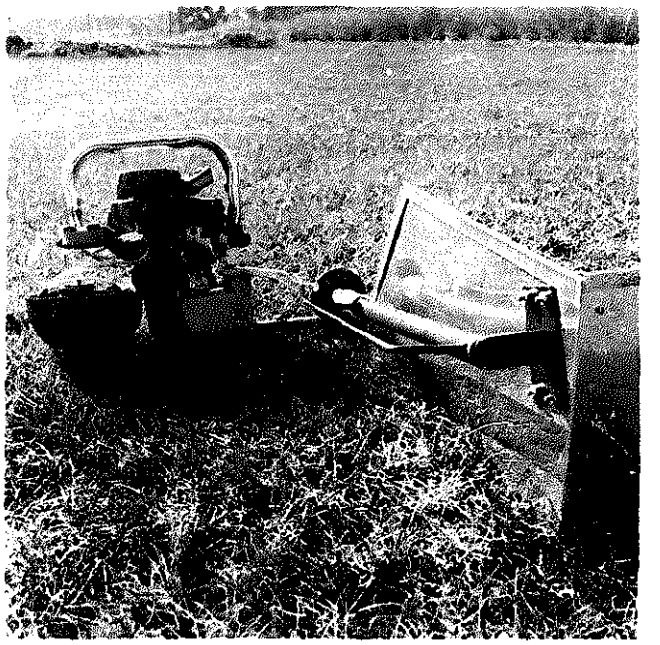
The harvester consists of a Little Wonder gasoline-powered, 76-centimeter (30-inch) hedge trimmer (Little Wonder, Inc., 1028 Street Rd., Southampton, PA 18966), with a lightweight aluminum tray attached to catch the grass seed heads when cut. This hedge trimmer has two sharpened blades that reciprocate in opposite directions to give excellent cutting action; they can be easily resharpened with a file. As the gasoline motor is self-contained, there is no need for an expensive generator and no cord to manipulate. The harvester's overall weight is only 7.3 kilograms, so it can easily be held and operated by one man.

The aluminum tray was constructed of 0.5-millimeter aluminum sheet. Tray dimensions are 58

* Adapted with permission from *Crop Science*, vol. 13, 1973.



A researcher harvesting seed heads with a gasoline-powered hedge harvester and collection bin attachment.



A close look at the catch bin adaptation.

centimeters wide, 56 centimeters long, and 23 centimeters deep. The sides are sloped 45 degrees at the front to allow the cut material to fall back into the tray without interference. The front of the tray has a lip formed downward three millimeters over the front of the blade, and it is attached to the top of the blade by the four bolts. The rear of the tray is supported by the handle that is attached near the top of the tray side. This gives the tray a downward slope to the rear and facilitates collection of the cut material in the tray.

The handle is 50 centimeters long to permit the operator to balance the harvester by adjusting the position where it is held. It is constructed of thin-wall steel conduit with an attached six-millimeter-diameter rod which activates the hedge trimmer clutch when the handle is rotated. This retains the safety feature of the trimmer; both of the operator's hands have to be on the handles for the blades to function. The main section of the handle is constructed of 2.3-centimeter-diameter thin-wall steel conduit, with a short length of 1.8-centimeter-diameter conduit welded on the front end and inserted inside the original trimmer handle. Another short length of 1.8-centimeter diameter is welded on the rear bracket and inserted inside the rear of the main handle. Plastic wedges are used to give a good fit between the two conduit sizes. Our cost for the harvester was just over $100 when we built it in 1973.

The harvester is operated by sweeping it into the grass with the blade just below the grass seed heads. Cutting into a slight breeze is helpful in moving the harvested material into the tray, but not necessary. The tray empties completely when the harvester is tipped forward, and no cleaning is necessary when changing varieties. The harvested material is emptied directly into large cardboard boxes or onto sheets of canvas where it is dried before threshing.

Tea Leaf Harvester

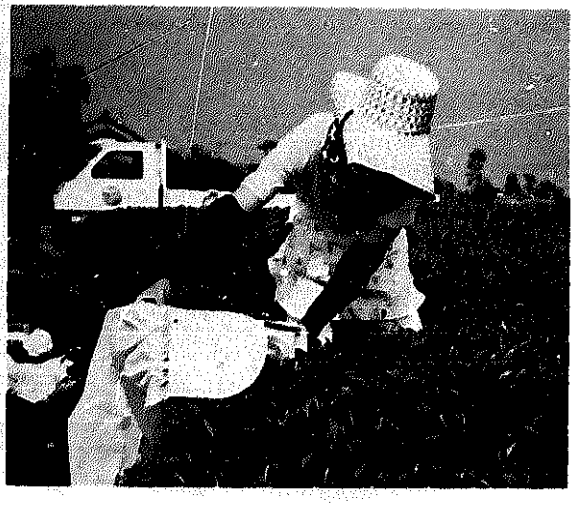
Utilizing the same theory as Smith's seed head harvester, the Japanese have devised a machine to pluck leaves from tea bushes. Reciprocating cutters and/or spindle reel mowers cut the leaves which are collected in a bag. Electric or gasoline-powered units are made for one or two people, and they are mounted on rollers wheels or carried by hand. Some blades are curved for aesthetic round-topped tea bushes or hedges.



A two-person design harvests more at once and leaves an aesthetic round-topped bush.
Kobayashi Cutlery



The carefully guarded spindle reel mower snips tea leaves . . .



. . . and delivers them to a catch bag.
Kobayashi Cutlery

Kobayashi Cutlery Mfg. Co., Ltd.
1131–Horinoachi Kikugawa–Cho
Shigwoka–Pref. Japan

NORTH AMERICAN SOURCES OF FORAGE MOWERS AND HARVESTERS

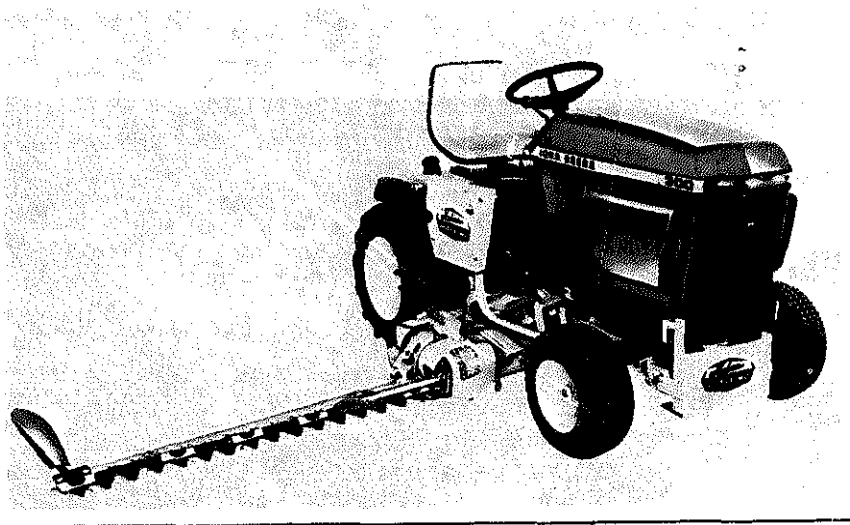
Haban Sickle Mo

Made for operation from the power take-off shafts of 20 h.p. tractors or less, the Sickle Mo makes a 4-foot cut with a full 3-inch stroke of the blade. Power is governed by a convenient clutch lever which actuates the drive belt. A full-floating action to the self-adjusting cutting bar keeps the blade level close to the ground. A swing back device permits the bar to move back instantly upon hitting a solid object.

Haban Mfg. Co.
2100 Northwestern Ave.
Racine, WI 53404

Jari

Cutting bars on the Jari cut a range of 16 to 60 inches. It is a self-propelled unit available



Haban 48" Sickle Bar Mower for lawn and garden tractors.
Haban Mfg. Co.

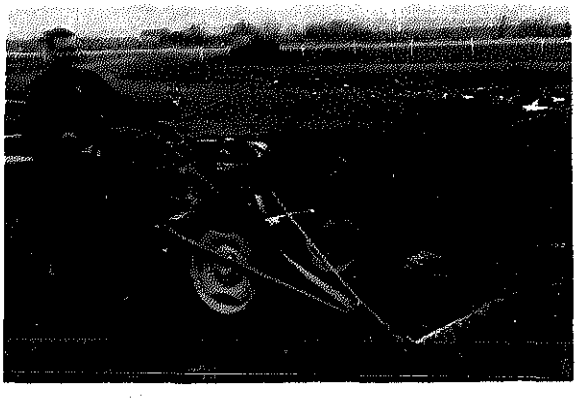
with a snowblower attachment. Separate controls engage the wheels and power unit.

Jari Division, Year-A-Round Cab Corp.
P.O. Box 2075
Mankato, MN 56001

BCS Mainline Sickle Bar

Manufactured in Italy, the BCS Mainline is a 13 h.p., gear-driven reciprocating mower with a 44-inch cutting bar. Sickle guards and swathboard ends are available, the latter designed to windrow the cut material. This unit has attachments for roto-cultivation, plowing, ridging, riding, and a trailer for transport. The manufacturer also offers a larger unit, which is discussed in the section on binders and reapers.

Central States Mainline Distributors
Box 348
London, OH 43140



BCS Mainline Sicklebar
Central States Mainline Distributors

Ferrari

The Ferrari walking tiller is manufactured in Italy. The handle pivots 180 degrees, allowing the tiller to be removed and a sickle bar attached. In this position, the unit runs backwards.

Ferrari
6104 Avenida Encinas
Carlsbad, CA 92008

Kinco

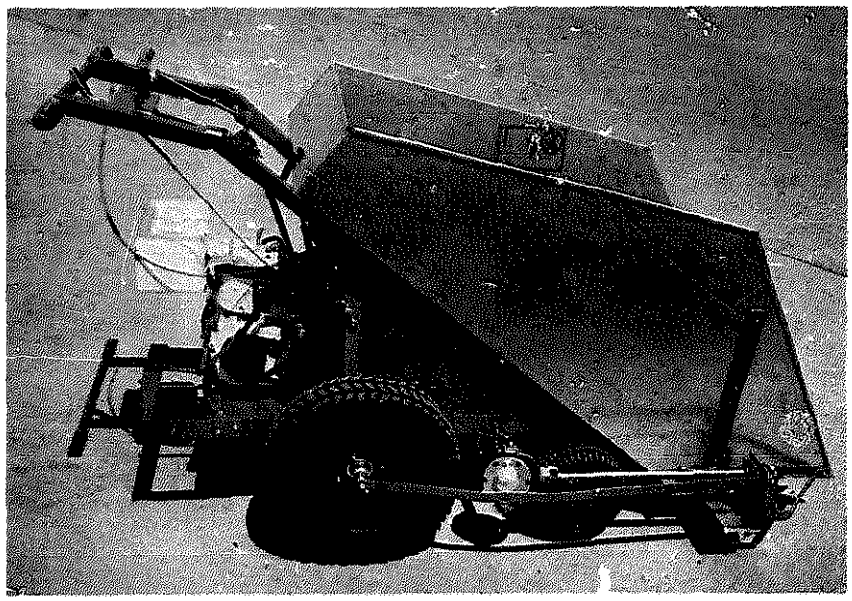
This is a 38-inch-wide sickle bar with wide tracking for stability on hills. Individual wheel clutches provide a source of power for easy turning. The knife disengages for transport.

Kinco Mfg.
168 N. Pascal
St. Paul, MN 55104

The Seedburo Plot Cutter

Designed for experimental work on research plots, the plot cutter is an 18-inch sickle bar mower with a collection bin for catching cereal crops as they fall back after being mowed. It has a variable ground speed control and complements the use of the Seedburo plot thresher.

Seedburo Equipment Co.
1022 W. Jackson Blvd.
Chicago, IL 60607



Seedburo Plot Cutter
Seedburo Equipment Co.

INTERNATIONAL SOURCES OF MOWERS

Bucher M600

The Bucher M600 walking mower has a 10 h.p., gasoline engine and a three-speed and reverse gearbox. It can be supplied with a windrowing attachment, trailer, and extra-wide wheels for stability on slopes. Other models are also available.

Bucher-Geyer, Ltd. Engineering Works
CH–8166 Niederweningen
Zurich, Switzerland

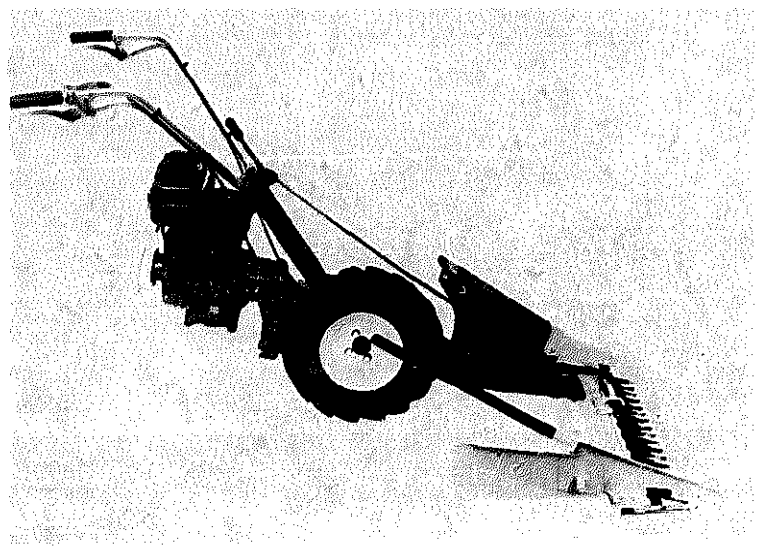
Gebruder M 6

The M 6 walking mower has been designed for mowing in all types of terrain. It has a 6 h.p. engine with a two forward, two reverse speed gearbox. It is fitted with a fingerless cutter bar.

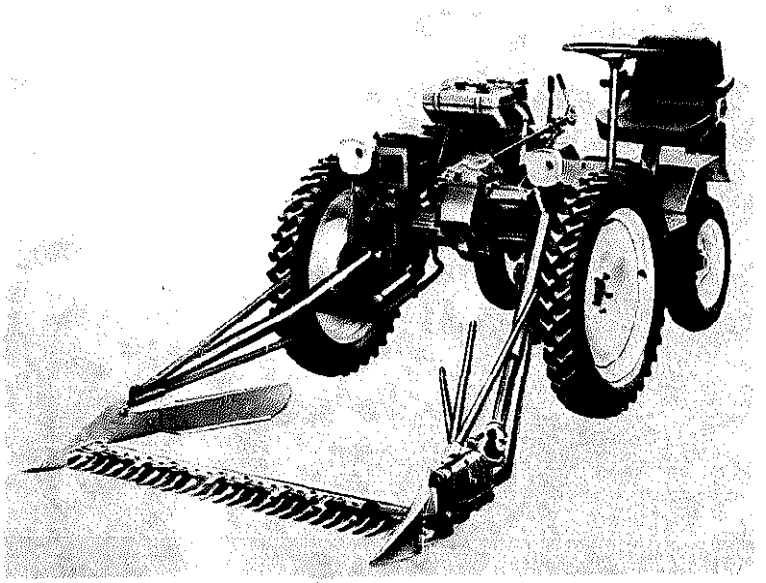
Gebruder Holder Maschinenfabrik
7418 Metzingen, Wurtt
Postfach 66, West Germany

Bertolini Mowers

Bertolini offers a 7 h.p. pedestrian and 14



Bertolini mower with only one wheel.
Bertolini Macchine Agricole



Bertolini 14 h.p. Riding Mower
Bertolini Macchine Agricole

h.p. riding mower. Both are suitable for cutting grass or grain crops.

Bertolini Macchine Agricole
42100 Reggio Emilia
Via Guicciardi 7, Italy

Schanzlin Mini Mower

This is a two-wheel pedestrian reciprocating mower.

Schanzlin Maschinenfabrik Gmbh
7831 Weisweil
Baden, West Germany

Freres SF8

This is a walking mower fitted with a 9 h.p. engine and a gearbox with four speeds forward and one reverse. Cutter bars of 1.10-, 1.27-, or 1.45-meter width are available. This mower may also be used to pull trailers and wheeled implements and to drive stationary machinery such as grinding mills.

Ets. Simon Freres
B.P. 47
50104 Cherbourg, France

Irus Power Mower

This mower has a 7 h.p. engine and can be supplied with cutter bars up to 1.40 meters wide, giving a work rate of 0.3 to 0.4 hectare per hour. A trailer, spraying, and pulling attachments are available for this two-wheeled power unit.

Iruswerke Dusslingen
7401 Dusslingen
Postfach 128, West Germany

MF-130

MF-130 motor mowers come with a 7 h.p. engine, two-speed and reverse gearbox. They are available with central or side-mounted cutter bar.

Macchine Agricole F.B.
36040 Sossano
Vicenza, Italy

M.R. Mower-Tractor

The steering handles on this mower can be set for driving in either direction. One direction is used for mowing and the other for rotary cultivating and trailer work. It is available with either an 8 h.p. gasoline or a 10 h.p. diesel engine. A special gearbox gives three forward and one reverse speed in both mowing and cultivating directions. Single-purpose mowers are also available.

S.E.P. Fabrica Macchine Agricole
Via Don Pasquino Borghi 6
42018 St. Martino In Rio
Reggio Emilia, Italy

AEBI

The Swiss AEBI two-wheel mower has a four-stroke, 10 h.p. gasoline engine with two forward and one reverse speed. It is specially designed for mountainous terrain, has 46-, 58-, and 66-inch cutting bars and a windrowing attachment which can be attached and removed without tools. (See walking tractor section for further details.) Various models are available.

AEBI & Co. AG
CH–3400
Burgdorf, Switzerland



The AEBI two-wheel mower.
AEBI and Co.

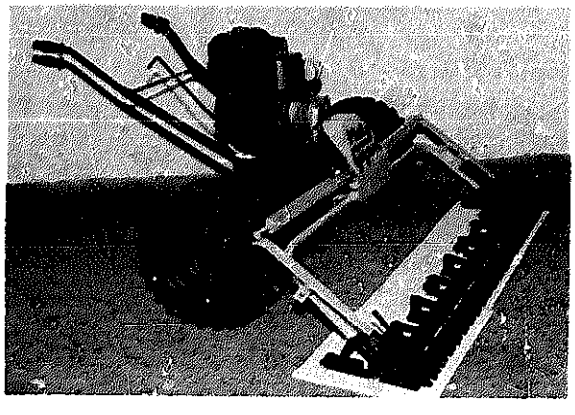
Bouyer

The Bouyer two-wheeled tractors have a lateral sickle mower mechanism with a mulch bar, but no windrowing attachment.

Bouyer
B.P. 23
Tomblaine 54510, France

Moty Universal and Gigant

The Moty Universal two-wheel tractor has a finger and double-acting cutting bar, 80 to 140 centimeters in width. Their Gigant four-wheeled, wide-wheelbase tractor will mow 5 feet at a time.



The Moty Gigant as a pedestrian mower with dual-wheel traction.
Moty-Werk



The Moty Gigant as a riding mower with four sets of dual wheels and a low center of gravity for serious work on hills.
Moty-Werk

Moty-Werk
8523 Frauental 62
Fernschreiber 3479
Steiermark, Austria

Hobby Models 80-2T, Elite 2T, Elite 4T

The Hobby is an extremely lightweight unit with an 80-centimeter-wide blade, adjustable cutting height, and optional two- or four-stroke motors. It is so lightweight, it is carried by the operator and simply lifted as mowing takes place. The larger Elite models have two wheels, one trailing the other. They are designed for smaller cutting jobs such as a small cereal plot would require.

Alpina
31015 Conegliano
S. Vendemiano (TV)
Casella Postale 44, Italy

Alpina North America
c/o Mr. H.J. Hutchinson
Box 313, Trail
British Columbia, Vir 466, Canada

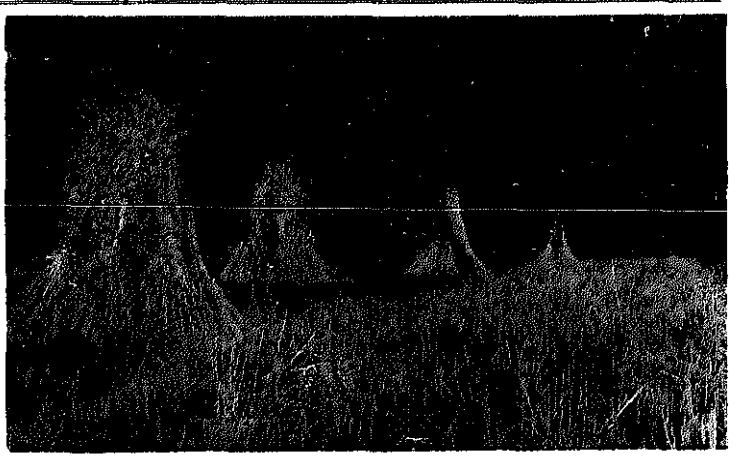
Agria Motor Mower 300

Powered by an air-cooled, two-stroke, 5 h.p. gasoline engine, the Agria 300 has a fingerless, 1.20-meter-wide cutter bar, adjustable handlebars, and one forward and reserve gear. Iron traction rings are available as wheel extensions for stability on steep slopes. A snowplow attachment is available also. Weight: 105 kilograms.

Agria-Werke Gmbh
7108 Moeckmuehl
West Germany

WINDROWERS AND BINDERS

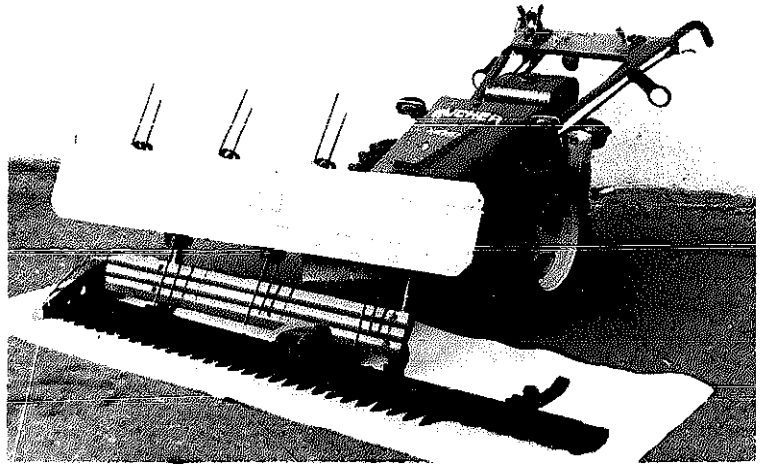
A windrow is a heaped row of cut vegetation. Grasses are raked into windrows to dry



Hand-tied sheaves are stacked in shocks to dry in the field.

before baling or storage. Delivering grain stalks neatly into a windrow as they are cut with a scythe and grain cradle facilitates bundling and eliminates the need for raking when harvesting by hand. Stalks are later tied into small bunches called sheaves which in turn are stacked and tied, butt end down, in larger bundles called shocks to allow grain heads to dry in the field.

In North America, hand harvesting has given way to a highly mechanized alternative, the combine harvester. This machine combines the cutting, gathering, threshing, and cleaning ac-



The Bucher M600 reciprocating mower with a windrower attachment.
Bucher-Geyer, Ltd.

tivities of grain processing into one large, expensive machine. It offers no practical alternative to hand harvesting for the small-holder in the size in which it is currently produced. However, in Europe, where homesteading has always been a way of life, a reciprocating mower with a windrowing mechanism is made to fit onto two-



The Bucher M600 with windrower at work.
Bucher-Geyer, Ltd.

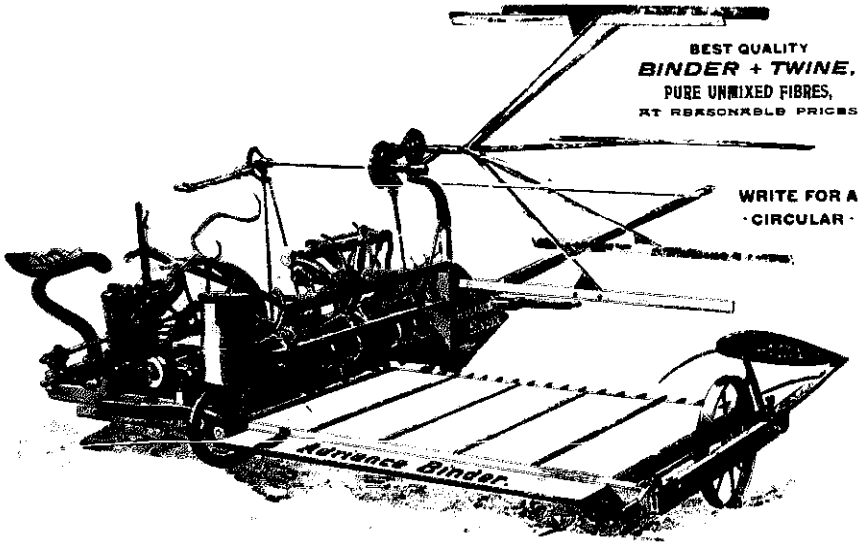


The AEBI walking tractor with an attachment for turning or windrowing hay.
AEBI and Co.

wheel walking tractors. Another attachment, the binder, has a rather complicated tying mechanism to carry out simultaneously the two operations of cutting a crop and tying it into neat and uniform sheaves. The binder basically consists of a reel to gather the crop for delivery to

the cutting mechanism, an elevating system of endless canvasses or a chainlike conveyor, and the binding mechanism which ties the cut material with a band of twine. Almost all of these parts are provided with adjustments so that a variety of crops can be harvested.

The binder has generally given way to the combine harvester for large-scale work. Until recently it was all but out of use in the United States except by conservative farmers of particular sects who have retained the old ways. But, recognizing a growing market for small-scale farming equipment, binders are making a comeback in North America.

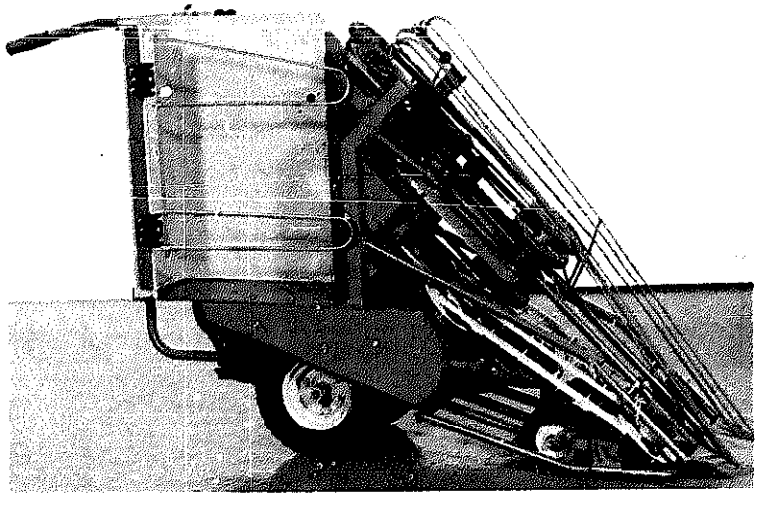


A late 19th century reaper-binder.
The Implement Age, 1894

NORTH AMERICAN SOURCES OF BINDERS

Ottawa Single-Row Harvester

Developed to harvest single rows of standing or lodged cereal plots for research purposes, this harvester is a compact, two-wheeled machine designed specifically for plot harvesting, with proper balance and convenient controls. Lodged crops are picked up by a pair of oblique-head finger bar assemblies mounted at 30 degrees at the front of the machine. As the straw is straightened by the dividers, it is gripped by elevating belts, cut 6 inches above the ground, and elevated to a hopper large enough to hold the yield of two 18-foot rows of cereal grain. The



Ottawa Single-Row Harvester
Agriculture Canada

harvester can be turned in a 5-foot pathway without declutching. Two 18-foot rows can be harvested by two men in one minute, including the time for unloading and cleaning.

Craftsman Machine Co.
61 Heaton
Winnipeg 2, Manitoba, Canada

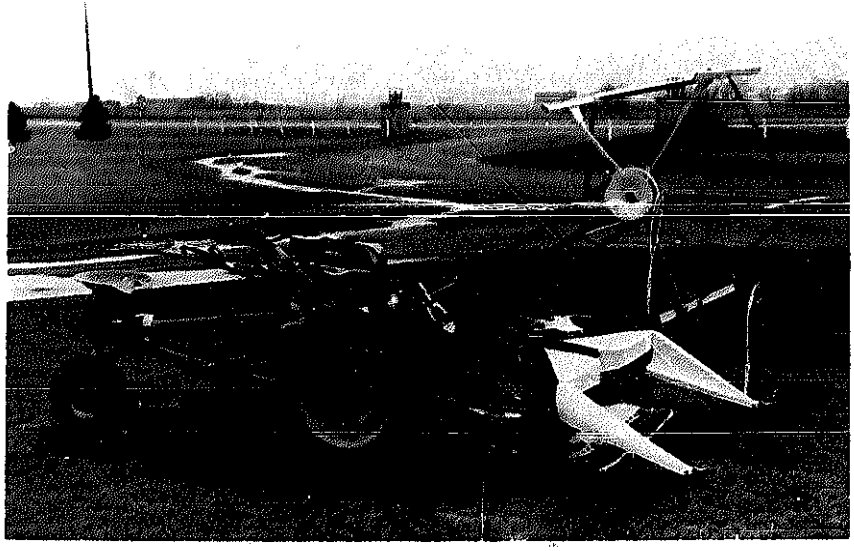
Winnipeg Plot Harvester

The Winnipeg research plot harvester is mounted on a standard 7 h.p. Gravely garden tractor. Modifications were made to the cutting bar to limit the cutting width to two rows seeded a maximum of 12 inches apart. Small wheels were added under the front end to raise the cutting bar to the desired height. The reel, driven from the front wheels, is adjustable horizontally and vertically. As the plot is harvested, the material is gathered in a pan and can be collected and tied by the operator. A small opening was left at the rear of the pan to facilitate cleaning between varieties. A bar was placed across the front opening of the tray, a few inches from the bottom to ensure that the reel will force cut material back into the pan and away from the cutter bar. With this machine, it is possible to harvest 1,000 rod rows daily without the back-breaking labor inherent in the old sickle method. Three men are required to operate this machine efficiently.

Machine Service & Repair, Ltd.
47 Landsdown Ave.
Winnipeg 4, Manitoba, Canada

BCS Binder

The BCS binder is a mass-produced farm machine from Italy which is mounted on the front of a European-style walking tractor equipped with a riding sulky. The tractor has a 9 h.p. engine, disc clutch, and a three-speed gearbox. The binder has a 54-inch wide cut and ejects the tied bundles to the rear. The crop remains in an upright position throughout the cutting and tying process. There is a provision for adjusting the size of the bundle, but not for tying height. Because the wheel tread is inside of the cutting width and the bundles are deposited on the stubble remaining where it was cut, adjacent plots are not disturbed. Optional equipment available from the factory includes a differential axle rather than the standard solid axle with wheel release, high-clearance axle, and electric starting. A mower attachment is included with the unit.



BCS Mainline Binder-Reaper
Central States Mainline Distributors

Ambassador Sales
Acton, Ontario
Canada

BCS Motofalciatrici
Viale Mazzini 161
Abbiategrosso, Milano, Italy

Central States Mainline Distributors
Box 348
London, OH 43140

INTERNATIONAL SOURCES OF BINDERS

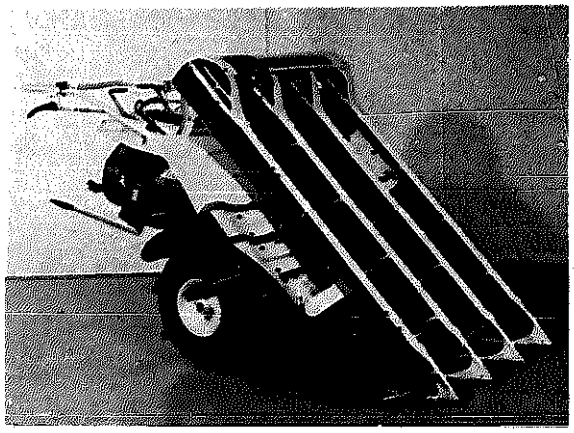
Walking Harvester Binder

This self-propelled reaper and binder is suitable for harvesting wheat or rice. It is available from Suzue in three versions: 1-wheel, 1-row reaping; 2-wheel, 1-row reaping; 2-wheel, 2-row reaping.

Suzue Agricultural Machinery Co., Ltd.
144-2 Gomen-cho, Nankoku-Shi
Kochi-Ken 783, Japan

Iseki Model RS300

A single-row reaper binder, its 3.85 h.p., four-cycle, air-cooled, gasoline engine has two forward and one reverse speed. Paddies of all heights ranging from 60 to 120 centimeters can be efficiently harvested.



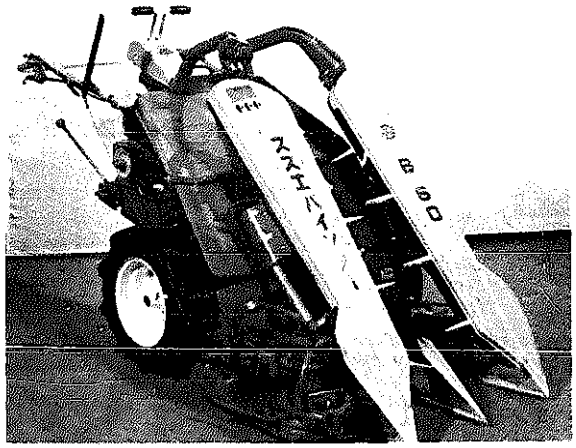
Kubota Harvester
Agriculture Canada

Iseki Agricultural Machinery Mfg. Co., Ltd.
1-3, Nihonbashi 2-chome, Chuo-ku
Tokyo 103, Japan

Models similar to the Iseki and Suzue binders for cutting and bundling rice and cereal crops are available from:

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

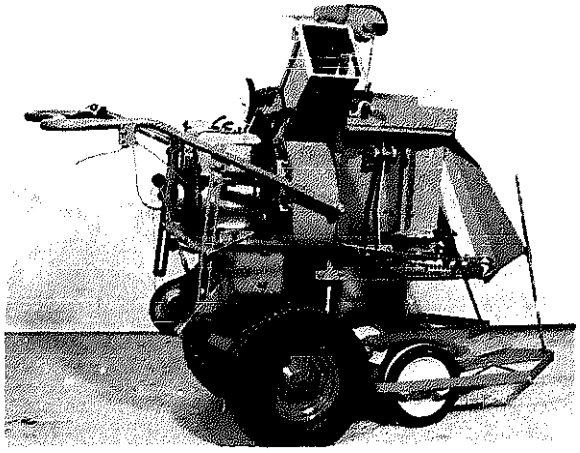
Kubota, Ltd.
22 Funade-cho, 2-chome, Naniwa-ku
Osaka, Japan



CeCoCo binder for rice and cereal crops.
Agriculture Canada

Vacuum Blower Harvester

The vacuum blower harvester was developed by the Engineering Research Service, Agriculture Canada to quickly harvest two-row research cereal plots by cutting a minimum amount of material and transferring the cut material directly into a bag. Attachments at the front hold the cutter bar and act as a pivot for the gathering mechanism. It is supplied with a two-speed transmission and an air-cooled gasoline engine. All functions are adjustable.



Vacuum Blower Harvester
Agriculture Canada

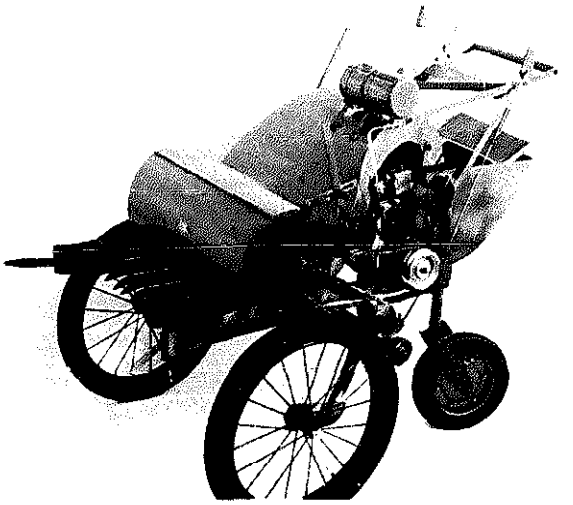
Craftsman Machine Co.
61 Heaton
Winnipeg 2, Manitoba, Canada

Poynter Stripper Harvester

The Poynter pneumatic stripper harvester uses a comb to guide standing crops into a cylinder where heads are removed and threshed by the combination of impact from the cylinder and stripping through the comb. The chaff is removed by an air blast created by the cylinder. The straw is not cut. The unit is self-propelled and has a 24-inch swath extendable to 36 inches by additional crop fingers. The height of the comb is adjusted by a hand crank during operation.

The Poynter box stripper is similar to the pneumatic stripper except that all the stripped material is collected in an 8-cubic-foot box. This type of stripper is used in conjunction with a plot thresher to further thresh the collected material. The box stripper is normally hand-propelled, but it is also available as a power-propelled unit.

Poynter Products Pty., Ltd.
52 Greenaway St.
Bulleen, Victoria, Australia

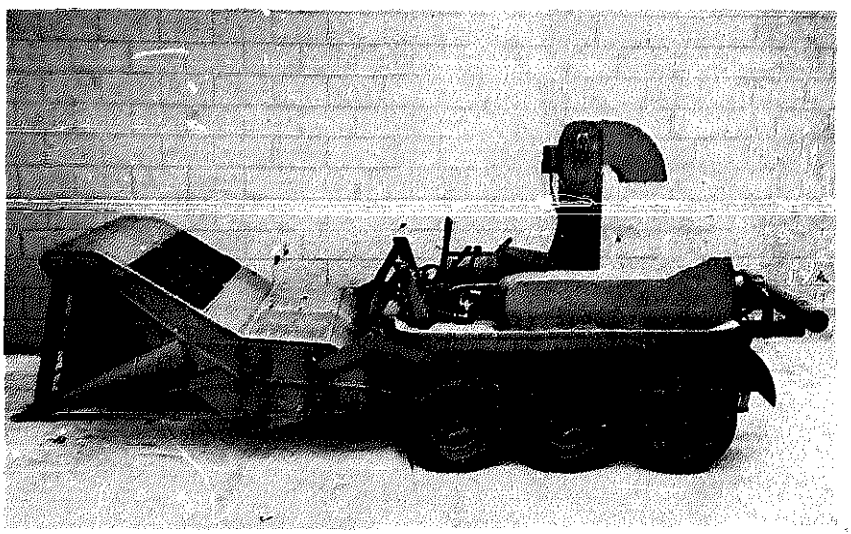


Poynter Harvester
Agriculture Canada

Similar harvesters are also manufactured by:

Monier Metal Products, Ltd. (Quick Harvester)
749 Port Rd.
Woodville, South Australia

Winter Industries Products Pty., Ltd. (Waite Harvester)
41 Lairna St.
Athol Park, South Australia



The IRRI Stripper Harvester, which is currently being developed in the Philippines.
International Rice Research Institute

IRRI Stripper Harvester

Presently under development at the International Rice Research Institute, the six-row stripper harvester is a somewhat expensive, labor-replacing machine, particularly suited for countries like Japan where labor costs are high. In



The IRRI Stripper Harvester in a field trial.
International Rice Research Institute

North America, a machine like this might offer an alternative to the combine harvester.

International Rice Research Institute
P.O. Box 933
Manila, Philippines

COMBINE HARVESTERS

As the name implies, a combine harvester-thresher performs the multiple operations of harvesting and threshing a crop in a single pass over the field, the sequence of operations being cutting, conveying to the threshing mechanism, threshing, winnowing, cleaning, and finally, either bagging or delivering the grain in bulk to a bin, and from there to a trailer or truck alongside the machine. Because each of these separate operations are performed at the same time in a combine harvester, the resulting machine is necessarily complicated and expensive.

A combine can also be used either to pick up and thresh crops which have been previously cut and left in the swath, or as a stationary thresher for handling crops which have been cut and stacked. Separate headers, front end reaping mechanisms, are required for harvesting cereal and maize crops. Special attachments allow some combines to windrow or chop and scatter straw as well. Earlier models of combines were pulled by a tractor; the cutting and threshing mechanism was driven either by an auxiliary engine mounted on the combine or by the tractor engine through its power take-off shaft. Modern combines are self-propelled.

The losses from combine harvesting may be quite serious unless a constant watch is kept for signs of unsatisfactory threshing. Conditions may change from one hour to the next, and it may be necessary to vary the adjustments several times during a day for best results.

THE FIELD FOR THE SMALL, COMBINED, HARVESTER-THRESHER*

By W. M. Hurst

Editor's note: A 1935 look at the harvesting needs of the small farmer reveals that little has changed in the past 40 years or more.

* Reprinted with permission from *Agricultural Engineering*, June 1935.

The development and widespread use of the combine was retarded for over 75 years because farmers, grain dealers, and farm machinery manufacturers thought it would work successfully only on the Pacific Coast. After the practicability of the combine had been demonstrated in the Great Plains states, it was predicted that its use would be restricted to areas where large-scale farming was practiced in dry areas. The demand for combines for harvesting soybeans in the corn belt, the introduction of the one-man combine, and the windrow harvester again made possible a wider use of this type of equipment.

Few, if any, agricultural machines are more efficient in performing the work for which they are intended than combines. However, the cutter bar is designed for heading ripe, dry grain and the cylinder, for threshing such material. In harvesting soybeans in the South, it is necessary to cut the plants within two or three inches of the ground and to handle a large volume of tangled vines and green weeds. In combining rice in the South, it is also necessary for the machine to handle not only green (unmatured) straw and weeds, but also much more straw than is customary in harvesting wheat.

The combine is also one of the few machines which may be purchased as well as operated at a lower cost than the equipment which it replaces. It is not, however, sufficiently low in first cost to permit its use on thousands of farms where general-purpose tractors are used. A small, inexpensive combine of somewhat different design than those now on the market would, it is believed, be used on many small farms in the east, north central, and some of the middle and south Atlantic states for small grain, in the south Atlantic and east south central states for soybeans, alfalfa, and clover, as well as a stationary thresher for cowpeas and other legumes.

For wider use in states east of the Mississippi River, the following features appear to be desirable and, in some cases, essential for a small combine:

1. Capacity to cut a 5- or 6-foot swath
2. A threshing cylinder designed for a large mass of straw and vines; possible width of the cylinder the same as the width of the cutter bar
3. A reel of such design as to gently pull the crop back on the elevator without shattering
4. An overall width of the machine to be not more than 12 feet, or of such design that not more than 15 or 20 minutes are required to get the machine in condition for transporting from one field to another
5. Weight from 2,500 to 3,000 pounds
6. A maximum cost to farmers of $500
7. Suitability for small grain, soybeans, and other legumes
8. Drive by power take-off from a tractor
9. Possession of a means for quickly adjusting concaves and reel—preferably from the driver's or operator's platform
10. A flexible mounting—pneumatic rubber tires or springs.

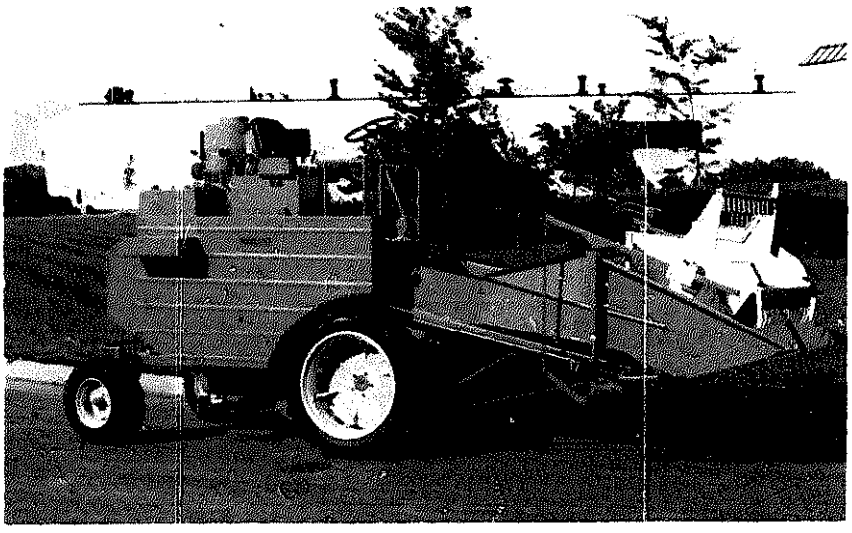
NORTH AMERICAN SOURCES OF COMBINE HARVESTERS

K.E.M. Research Plot Combine Model SP 50

Available for about half the price of the smallest popular farm combines in the United States, the K.E.M. Research Plot Combine has a large-capacity cylinder and a wide range of speeds making it possible to harvest a wide variety of crops. This self-propelled unit employs a 17.5 h.p. gasoline engine and a hydrostatic ground drive with infinite speeds forward or reverse from 0 to 6 mph. The threshing mechanism utilizes a 15-inch by 27-inch rasp bar cylinder and an air and shaker sieve after cutting a 54-inch swath. The header is comprised of a sickle bar cutter and guards, a power reel with delivery to the cylinder by a 27-inch wide conveyor belt, and hydraulic lift.

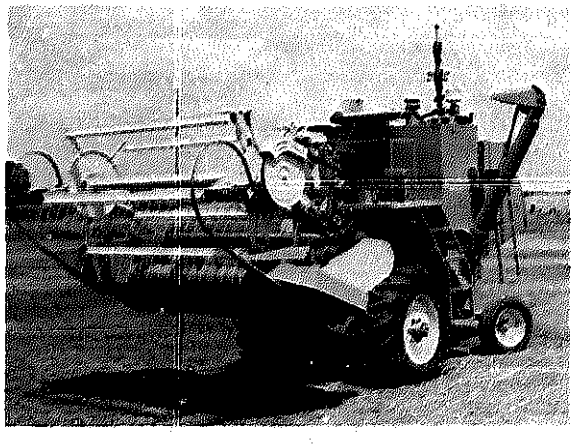
K.E.M. SP 4000

Much larger than K.E.M.'s SP 50, this research plot combine has a 53 h.p., gasoline,



K.E.M. Research Plot Combine SP 50
K.E.M. Corp.

four-cylinder, Volkswagen engine. It has a 12-inch ground clearance, weighs 6,800 pounds (shipping weight), and has overall dimensions of 208 by 75 by 118 inches. The hydrostatic ground drive has two speeds for a traveling speed ranging between 0 and 12 mph. It comes with two adjustable sieves and a 27- by 80-inch straw rack. It can cut a width of 7 feet and has a 28-bushel-capacity grain tank. With grain and corn headers, it has multicrop versatility.

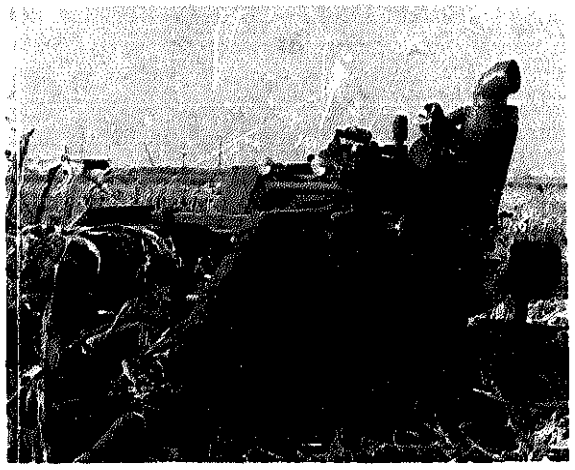


SP 4000 Combine
K.E.M. Corp.

Kincaid Equipment Mfg. Corp.
P.O. Box 471
Haven, KS 67543

ALMACO C-F Plot Combine

This combine, designed for research test plots of small grains, corn, and soybeans, is self-propelled by a 37 h.p. gasoline engine. Its hydraulic system powers the forward and reverse drives, the variable speed thresher, the lift on the header assembly, and reel and drive on the variable-speed reel. It has an underslung, self-cleaning, adjustable, concave rasp bar. The 51½-inch sickle bar cutter is accompanied by headers for small grains and corn which have bean saver snouts for soybean harvesting. It weighs 5,000 pounds, is 17 feet 6 inches long and 7 feet wide.



The ALMACO Plot Combine with a corn header.
Allan Machine Co.

Allan Machine Co.
P.O. Box 112
Ames, IA 50100



The ALMACO Plot Combine with a soybean header.
Allan Machine Co.

INTERNATIONAL SOURCES OF COMBINE HARVESTERS

CeCoCo Midget Combine

To thresh grain in a traditional fashion, men and women swing sheaves over their shoulders and beat them down into a tub, or they have buffaloes and oxen tread on them. These methods result in significant grain losses due to shredding, incomplete threshing, and a high incidence of grain damage.

The people at CeCoCo explain that "the need for a simple and efficient rice combine is essential. The shortage of labor has made it difficult to reap sufficiently fast, creating a bottleneck at harvest time. Furthermore, the loss and damage incurred by the traditional methods of harvesting and threshing could not be afforded in view of the rapidly increasing population and its inherent food problem."

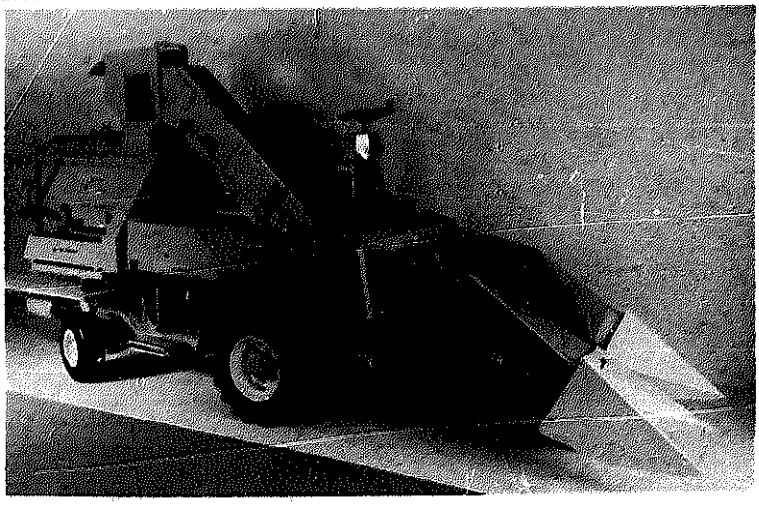
To solve this problem, they have developed the CeCoCo Midget Combine. Their 6 to 9 h.p. unit with six forward and two reverse speeds is claimed to reap and thresh approximately 1 acre of rice, wheat, or barley per 8-hour day, utilizing an air current design. This is one modern machine which helps to improve the soil organically, since straw is left in the field to rot into humus.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Iseki

Iseki manufactures two combine harvesters. Model HD660R has a 9 to 12 h.p., air-cooled, four-cycle gasoline engine and it is capable of covering 1.5 to 2.5 acres per 8-hour day. The harvesting mechanism employs a reciprocating mower for cutting and a Japanese type of thesher. It discharges the hay at intervals in fixed quantities to facilitate pickup. Their larger model, the Cosechadora HD 2000, has a 25 h.p., water-cooled engine which will harvest from 4 to 6 acres in an 8-hour day.

Iseki Agricultural Machinery Mfg. Co., Ltd.
1-3, Nihonbashi 2-chome, Chuo-ku
Tokyo 103, Japan

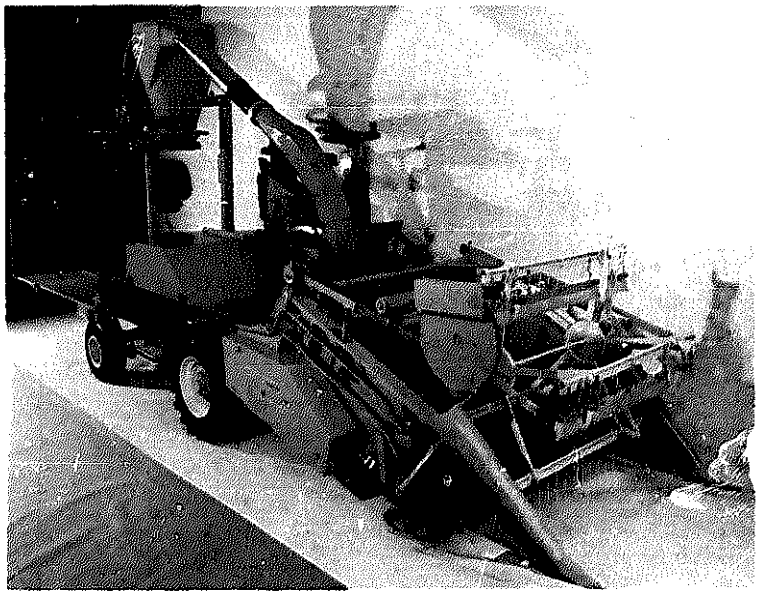


The Wintersteiger Kultraplant with a corn header.
Walter & Wintersteiger

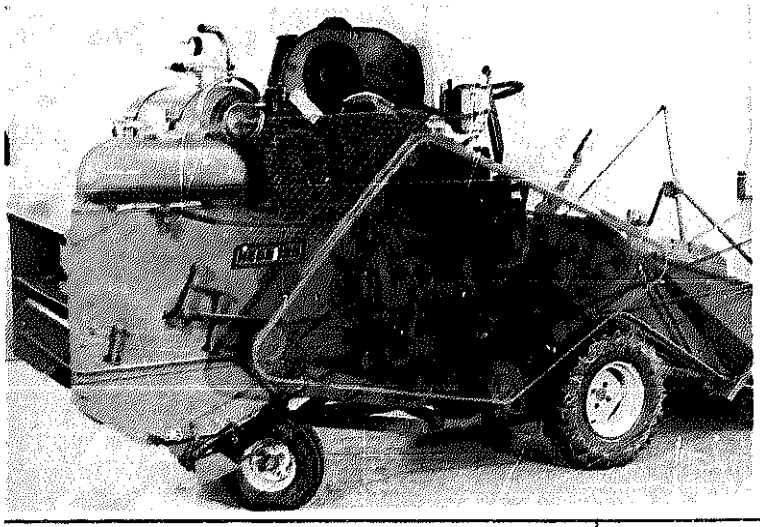
The Kultraplant Pam 150-S

A self-propelled combine with a 63-inch cut, the Kultraplant is specially designed for small seed plots. The table, reel, and cylinder are comparable to a conventional combine, but seed is separated by air currents. The unit is powered by a Volkswagen engine and has three speeds forward and one reverse with a device to vary the speed in each gear. Cleanup time is claimed to be 1 minute. A 180-degree turn can be made in a pathway 20 feet wide, and the wheel tread is inside the width of the cut.

F. Walter & H. Wintersteiger
K.L., A–4910 Ried im Innkreis
Dimmelstrasse, Austria



The Wintersteiger Kultraplant with a bean header.
Walter & Wintersteiger



Hege Combine
Agriculture Canada

Hege 125

According to Agriculture Canada, the German Hege 125 differs from the Pam 150 in that it has straw walkers and a short cleaning sieve. A wide rubber belt is used to convey cut material to the cylinder; it does not have a reel. There are viewing doors to the screens and straw walkers. An overcapacity fan is used to blow the separating area clean at the end of each plot.

The cutting width is 49 inches, the total

length is 12.8 feet and total width, 51 inches. This combine is also powered by a Volkswagen engine with a combined four-speed transmission and variable-speed drive. It is possible to cut a plot 39.7 inches wide and 32.8 feet long in 1 minute, including the time to clean the machine. Models are being used at Oregon State and North Dakota State Universities in the United States.

Hans-Ulrich Hege
Saatzuchtmaschinen
7112 Domane Hohebuch
Waldenburg/Wiirtt, Germany

United States Parts outlet:

H & N Equipment, Inc.
Colwich, KS 67030

Garvie Plot Combine

The Garvie Plot Combine, developed by the National Institute of Agricultural Engineering in Great Britain, employs a canvas to convey the cut material to a rasp bar cylinder with a grate-type concave. Threshed grain falls through the concave to a conveyer belt which carries it to a grain pan. Straw is thrown into a collection bin and then removed by hand. The straw must be shaken when removing it to shake out any grain still in the straw. A special cleaner has been developed to further clean the sample.

The cylinder is direct-driven from a 7 h.p. engine. Wheel drive is by fixed displacement, double-volume, hydrostatic transmission to a single rear wheel, giving speeds of 1 or 3 mph in forward and reverse.

The total width of the machine is 4 feet 10 inches and the overall length, not including the reel, is 12 feet 3 inches. The driver sits at the side of the machine. Capacity is about 20 four-row, 10-foot plots per hour.

R.G. Garvie & Sons
2, Canal Rd.
Aberdeen, Scotland

Stationary Combines

Two makes of small European combines with 7-foot tables are available fitted with a large air compressor and nozzles located at strategic positions to make the combine self-cleaning. Also, extra rubber parts are fitted to the elevator flights.

Bolinder Mumktell
Eskilstuna, Sweden

W. Rosenlew & Co.
A.B. Engineering Works
Pori, Finland

Suzue Combine

Another combine to accommodate the average 3-acre Japanese farm is mounted on a walking tractor chassis and is available with wheels or tracks. The combine is unconventional in that air currents are used for the reel and for separation after threshing. Heads are cut off by contra-rotating rotary cutters at the front. Two threshing drums thresh the cut crop and deliver the material to the airstream in the cleaning section; the chaff and short straw is thrown out by a blower. The cleaned grain is then fed through an auger to a blower which blows it into a sack. The remaining stubble is cut into 5- to 6-inch pieces by circular cutters at the rear of the machine. A capacity of 1 acre per day is claimed. The combine is powered by a 9 h.p. kerosene engine and has a six-speed gearbox with a unique locking axle that gives good traction and maneuverability.

Suzue Agricultural Machinery Co., Ltd.
144-2, Gomen-cho, Nankoku-Shi
Kochi-ken 783, Japan

Sold by:

Nissho Canada, Ltd.
100 University Ave.
Toronto, Ontario, Canada

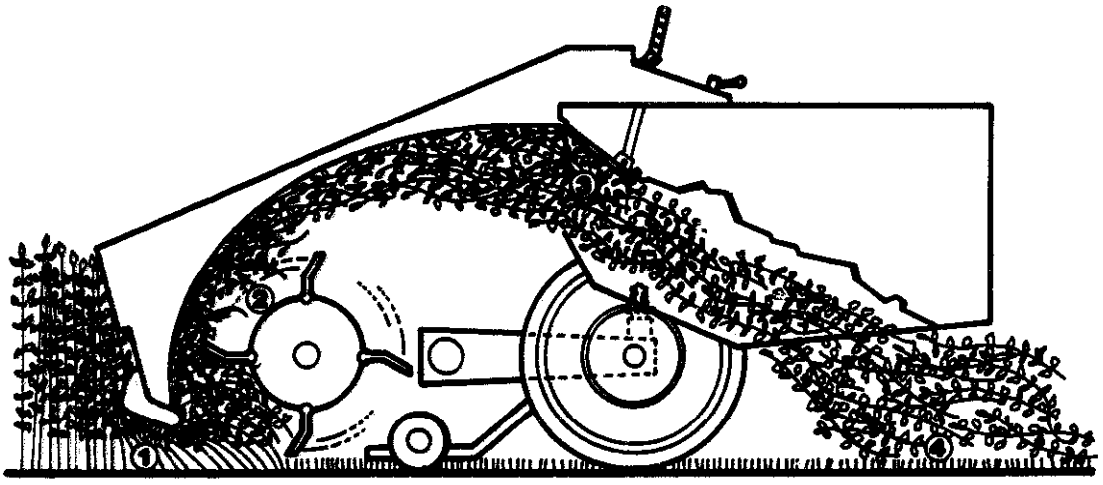
FORAGE CROPS

FORAGE HARVESTERS

The forage harvester has been developed fairly recently for collecting grasses or other forage crops from the field in their green stage

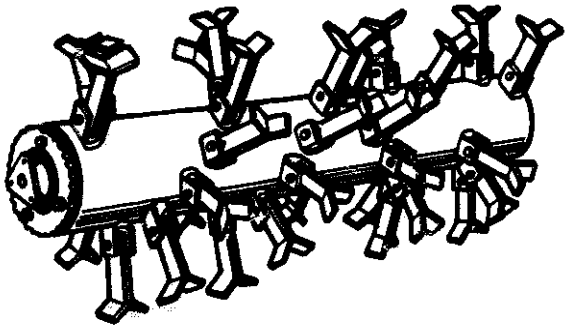
to be used later for making either silage or artificially dried feed. Earlier models of a field forage harvester consisted of a stationary chopper-blower mounted behind a reciprocating mower or behind a pickup reel for collecting previously mown grass. Power to the chopper-blower was provided either by an independently mounted engine or through the power take-off shaft of the driving tractor. However, these models have now been largely superceded by the modern flail-type forage harvester where the mower unit or the pickup reel and the chopper-blower are no longer used.

The principle of operation involves flails, or blades, which are hinged on a shaft or cylinder which rotates at a high speed as the machine is being driven forward. The flails cut the stationary vegetation by impact, in a manner similar to a hand-operated grass slasher or a conventional rotary lawn mower. Rotating at high speed, they also act as a fan and provide a draft of air and the necessary momentum for blowing the cut material up through an elevated exit spout. The shape of the spout directs the cut material into a trailer at the rear with the help of an adjustable end flap. The height of the cut is regulated by adjusting the wheels on which the machine is mounted. Some flail mowers simply cut high grasses and leave them in the field to be raked or baled.



1. *The full-width adjustable crop deflector bends standing plants over so knives can cut stems close to the ground. Once cut, the stems are conditioned by repeated light contact with knife edges, ensuring uniform, effective conditioning and soft, palatable hay.*
2. *At a maximum speed, plants move up and over the rotor without further contact with the knives so the upper leafy portions of the plants are undamaged.*
3. *A deflector at the rear slows down the speed of the plants and also fluffs and directs the hay down to the rear.*
4. *Cut and conditioned material falls gently on top of the stubble into a loose, fluffy swath or into a neat windrow of your selected width and density, depending on shield adjustment.*

Avco Corp.



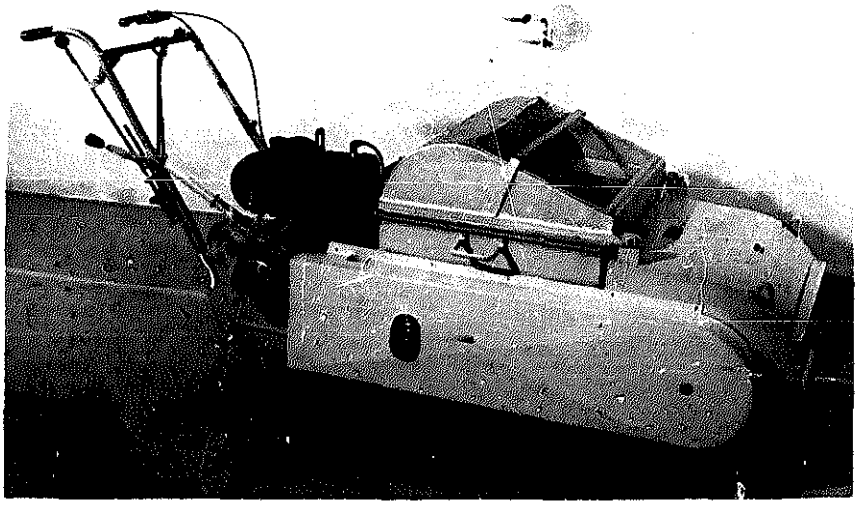
The Flail mower consists of a solid shaft with loosely hung, pivot-mounted blades rotating at high speeds. This creates a tremendous chopping action, pulling material in from the front, shredding it, and distributing it evenly over the field. The blades simply fold back when they strike rocks or debris, returning to a cutting position when the obstruction is passed over.

The modern forage harvester, built as a compact power take-off-driven unit, can perform the multiple operations of cutting, chopping, and loading green grass, dry hay, and other silage crops into a trailer in one pass over the field. It can also be used as an implement for the care of meadowland by cutting local concentrations of coarse grass and weeds, for distributing manure, and for removing molehills.

NORTH AMERICAN SOURCES OF FORAGE MOWERS AND HARVESTERS

Swift Current Harvester

The Swift Current forage plot harvester cuts forage material with a flail-type cutter and delivers it to a collection bin. The harvester is a two-wheel walking-type powered by a 7 h.p. engine. The width of cut is 24 inches, and grasses, legumes, or corn up to 3 feet high can be harvested. The sample box holds 6 cubic feet and is hinged so that it may be emptied by one person. An improved model is now available.



Swift Current Forage Harvester
Agriculture Canada

REM Mfg.
Swift Current
Saskatchewan, Canada

KEM Plot Forage Harvester

The Kincaid Plot Forage Harvester was developed for cutting crops when there is a need for weight data in research experiments. It is also used on small plots when crops must be harvested in a stationary thresher. Maneuverability is good, and steering is accomplished by use of two hydrostatic pumps. This enables it to be used in very small areas. The pickup reel is effective in lodged crops, and the pickup angle on the bats is adjustable by a rotating cam plate on the end of the reel. The collection box is easily dumped. Pickup reel, hydraulic header lift, header gauge wheels, and electric start are all standard equipment. It measures 56 inches by 49 inches by 156 inches, weighs 1,520 pounds, utilizes a conventional sickle cutting bar in 3-inch sections and uses an 8 h.p. engine for cutting a 54-inch swath.

Kincaid Equipment Mfg. Corp.
P.O. Box 471
Haven, KS 67543

Mott Model J-60

Model J-60 is a 60-inch, rear-mounted mower designed specifically for the Kubota L15 or other compact tractors (see chapter four). With a modified three-point hitch, it runs off a tractor power take-off with a 25 h.p. maximum. It can be used to mow lawns, and shred weeds for mulch, as well as cut up forage crops. A unit like this is particularly helpful to the organic farmer who wants to incorporate organic material into the soil with rototilling blades but who needs to have the crop residue finely chopped first to avoid clogging the tines. The mower will leave

stubble ¾ to 3 inches high and cut a 60-inch swath. A triple-mower gang arrangement is possible for a swath of 10 feet 4 inches. This arrangement utilizes two self-powered trailer-type mowers with 8 h.p. engines.

Mott Model 18-60

Designed specifically for the front power take-off of the Bolens 1886 tractor, this front-end, 60-inch model employs hammer knife safety flails as the cutting tools on this unit. The knifelike flails have an edgewise cutting action which provides a cleaner cut and uses less power than conventional flail mowers. It is called a safety flail mowing system because, being lightweight and free swinging, the flails fold back when hitting an obstruction to absorb the force of impact and minimize the danger of objects being thrown by the blade.

Mott Model T38

A unit to be towed, the T38 cuts a 38-inch swath and employs an 8 h.p. engine. It attaches quickly to any tractor drawbar with a cotter pin.

Other units are available specifically designed for most major farm and garden tractors, including the Allis-Chalmers 616 and 620 and the John Deere 300 and 400 tractors.

The above harvesters are manufactured by:
Mott Corp.
500 Shawmut Ave.
Le Grange, IL 60325

Gehl FC72C Chopper

Gehl offers a wide range of large forage harvesters, and their smallest unit, the FC72C flail chopper, requires a 40 h.p. tractor or larger.

Gehl Co.
West Bend, WI 53095

Western Bear Cat Chopmaster

The Chopmaster requires the power of a two- or three-plow tractor for cutting a 6-foot swath of corn or cotton stalks and for mowing jobs. It operates from a 540 rpm power take-off shaft and fits any drawbar. Models are available with or without a blower, a discharge elbow, a cutter head, or an auger.

Westernland Roller Co.
Hastings, NE 68901

New Idea Cut/Ditioner

New Idea offers a 7-foot windrowing mower requiring a minimum of 40 h.p. as their smallest unit.

AVCO Corp., New Idea Farm Equipment Div.
First & Sycamore
Coldwater, OH 45828

Haban Flail Mo

The Flail Mo is designed for front mounting on compact tractors of 7 h.p. or more. Two sizes are available, a 36-inch size with 80 knives and a



Haban's 12 h.p. self-propelled flail mower, complete with riding sulky.
Haban Mfg. Co.

48-inch size with 120 knives. It will cut tall grasses and brush to a minimum height of 1 inch without throwing stones. Depending upon conditions, it can be operated at speeds from 1 to 4 mph.

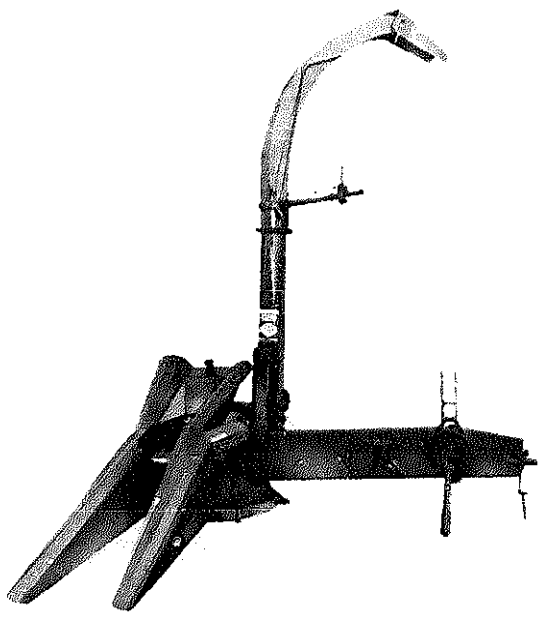
Haban Mfg.
2100 Northwestern Ave.
Racine, WI 53404

INTERNATIONAL SOURCES OF FORAGE MOWERS AND HARVESTERS

Jumil JF-1

The JF-1 operates at a rate of 8 kph for an output of 15 tons per hour from a tractor's power take-off shaft. A 35 h.p. or larger tractor is required to power the unit.

Jumil
Justino de Morais, Irmaos S.A.
Rua Ana Luiza, 568 Cx. Postal 75
Batarais, Brazil



Jumil JF-1 Jumil



Hay harvesting in the late 1800s. The Implement Age, 1894

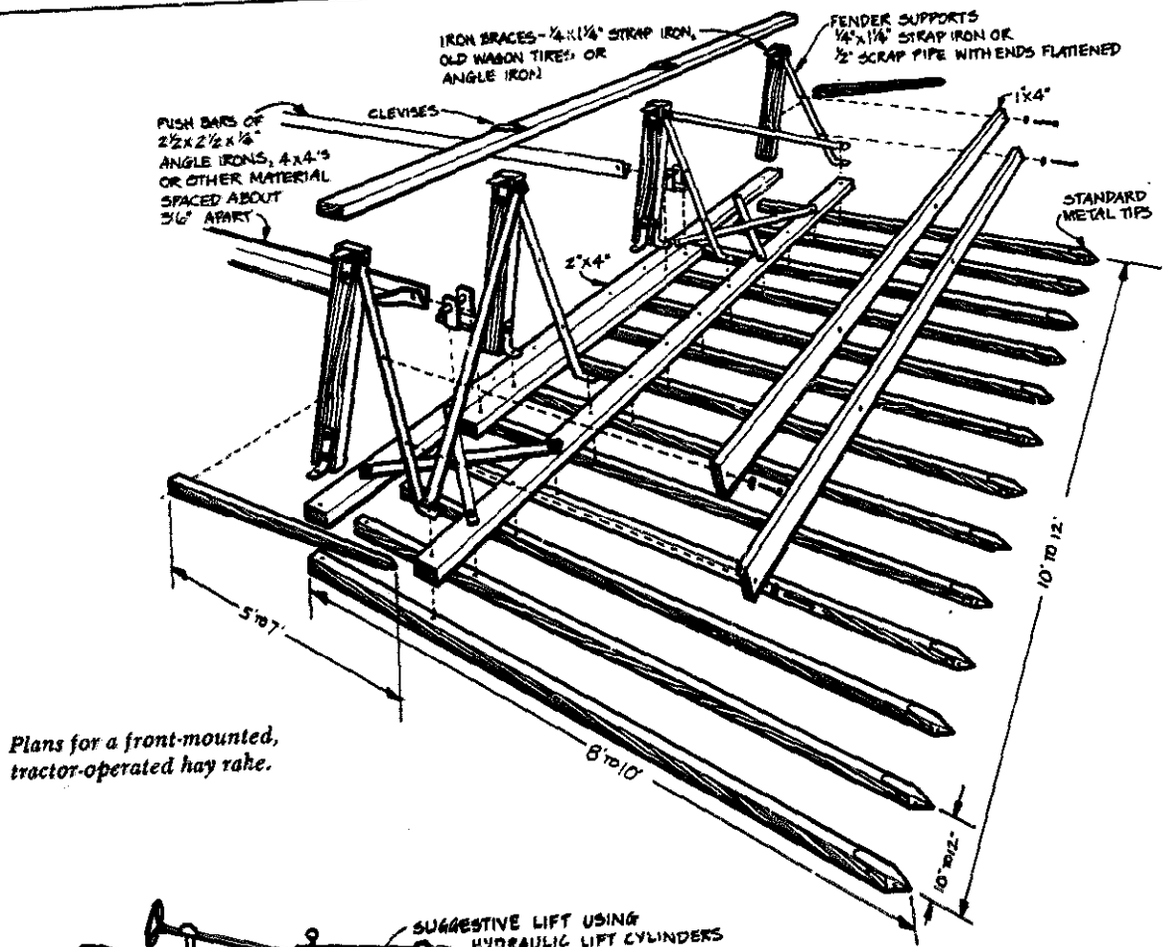
RAKING HAY

Once forage crops are cut and allowed to dry, they have to be gathered. The Rake Factory in Suffolk, England is still making hay rakes by hand, along with their handmade wooden scythe snaths. Wide, lightweight wooden rakes with long pegs for teeth are used for raking by hand. An early method of hay collection was a ground-driven, animal-drawn contraption with raking arms which carried hay up a primitive (but clever) type of conveyor and dropped it onto a wagon.

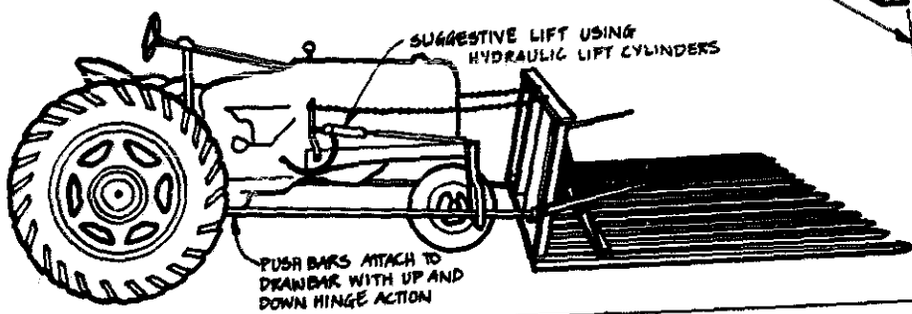
Today, baling is popular but most balers require the power input of a large tractor. However, one Italian manufacturer makes a baler attachment for a two-wheel tractor. They are Pasquali Macchine Agricole, Via Nuova 30, 50041 Calengano (Frenge) Italy. In North

America, you can write to Pasquali USA, P.O. Box 6235, Verona, WI 53716.

The Texas Agricultural Extension Service of the Texas A & M University System has developed detailed building plans for a raking attachment for the front end of a tractor. Made of wood, the rake becomes slick and slippery with use and glides easily across hay stubble. A hydraulic lift facilitates unloading hay onto a cart.



Plans for a front-mounted, tractor-operated hay rake.



HARVESTING CORN

Corn is grown as a row crop, and because its stalks are rather thick and tough when mature, specialized equipment is necessary for harvesting the crop by mechanical means. For small acreages under the peasant farming system, harvesting is still carried out by hand.

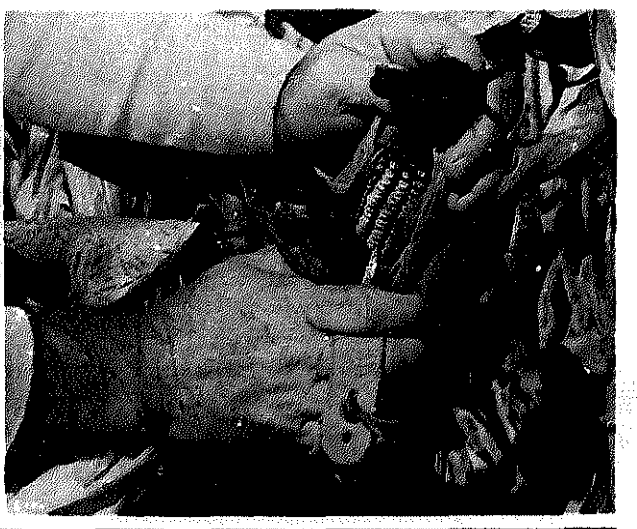
HAND HARVESTING

Corn Pegs

The easiest way to harvest corn by hand is to allow it to hang on the stalk until the plant is dead and brown. Then, move down one row after another, husking the ears and tossing them onto a wagon, cart, or pickup truck. In the past, farmers used many kinds of husking pegs strapped to their fingers or the palm of one hand to rip the husk loose from the ear with one swift downward motion. The original husking peg was a simple piece of wood or bone about ¼-inch in thickness, sharpened to a point at one end, and held in the middle joint of the fingers of the right hand. A string or leather thong held it to the fingers. The husker would slash open the husk with the point of the peg, grab a section of husk between thumb and peg, and tear it off the ear. You can do the same with your fingers, but it takes longer and is harder on the fingers.



Husking Peg.



Stripping the husk away.

Over the years, improvements came to the husking peg, the ultimate being a sort of fingerless leather glove with a steel plate riveted to it. The plate had a steel hook on it which ripped open the husk when the husker ran the palm of his hand down the ear of corn. A good husker could perform this operation with amazing speed and skill and could husk a bushel of corn from the stalks in less than a minute.

Corn Knives

A simple tool called a corn knife, shaped like a sword or machete, is used to cut stalks about 4 inches from the ground. Some have long handles and serrated edges.



Corn Knife.



Chopping cornstalks with a corn knife.

NORTH AMERICAN SOURCES OF CORN-HARVESTING TOOLS

	CORN PEGS	CORN KNIVES	MACHETES & HARVESTING KNIVES
AMES		X	
BELKNAP, INC.		X	X
COLUMBIAN CUTLERY CO.		X	X
CUMBERLAND GENERAL STORE	X	X	X
GLEN-BEL'S COUNTRY STORE		X	
LEHMAN GOOD NEIGHBOR CATALOG	X		
A. M. LEONARD & SON, INC.			X
BEN MEADOWS CO.			X
MOTHER'S GENERAL STORE CATALOG			X
NASCO AGRICULTURAL SCIENCES		X	X
NORTHEAST CARRYING TRADING CO.		X	
SEYMOUR MFG. CO.		X	
THE UNION FORK & HOE CO.		X	

INTERNATIONAL SOURCES OF CORN-HARVESTING TOOLS

	CORN KNIVES	MACHETES & HARVESTING KNIVES
FERFOR		X
KUMAR INDUSTRIES		X
LASHER TOOLS PTY., LTD.	X	X
RALPH MARTINDALE & CO., LTD.		X
SHW SCHWABISCHE HUTTENWERKE GMBH		X
SELF-SUFFICIENCY AND SMALL-HOLDING SUPPLIES		X
SOCIETE DES FORGES TROPICALES		X
FRANZ SONNLEITHNER K.G.		X
SPEAR & JACKSON TOOLS, LTD.		X
SYNDICAT DE L'OUTILLAGE AGRICOLE ET HORTICOLE		X
UBUNGO FARM IMPLEMENTS		X
WOLF AND BANGERT WERKEUGFABRIK		X

MECHANICAL CORN HARVESTERS

Corn Binder

Rarely used anymore, a corn binder could still be handy on a homestead if one could be found in running order. Just as with grain, the binder cuts the stalks of corn with a small reciprocating sickle bar, then bunches and binds the stalks into bundles with an automatic tier. Binders were made for use with both horses and tractors, and some were powered by the tractor's power take-off.

Corn Picker

The commonly accepted colloquial name for the machine that replaced binders and the old method of harvesting corn is a corn picker. The picker strips the ear off the stalk as the machine moves down the row, husks the ear, and tosses it into a trailing wagon, leaving the stalk standing. One-row pickers are commonly available in the Corn Belt region of the United States and would suit many small homestead operations.



An old one-row, pull-type corn picker with a conveyor and PTO connection.

Mechanical single- or multiple-row pickers are equipped with snapping rolls to remove the cobs from the standing stalks. The power required to operate the machine is provided by the tractor's power take-off shaft, although self-propelled units or those mounted integrally on the tractor are also available. The machine is provided with a gatherer, or header, which guides the standing stalks in a row along a throat to the revolving, snapping rolls, where the cobs are pinched and snapped from the stalk. The cobs then drop onto an elevator system for conveyance to a trailer which is drawn beside or behind the machine. Most harvesters do not cut the stalks from the ground.

A simple, snapper type of corn harvester does not remove the husks from the cob, while a picker-husker is equipped with a husker attachment for removing the husks after snapping. A more recently developed machine is capable of shelling corn in the field after snapping and husking; another type can also shred the standing stalk after the cobs have been removed. Corn harvesters are generally classified according to the number of rows harvested and the way in which the machines are attached to the tractor.

SOURCES OF CORN HARVESTERS

New Idea One-Row Snapper and Superpicker

New Idea offers two corn pickers which can be operated with a minimum of a 35 or 40 h.p. tractor, with power to spare for pulling a loaded wagon behind. The picker removes husks but leaves kernels on the cob while the snapper leaves husks on as well. The picker weighs 2,400 pounds, the Snapper less than 2,000 pounds.

AVCO Corp., New Idea Farm Equipment Div.
First & Sycamore
Coldwater, OH 45828



New Idea Corn Harvester.
Avco Corp.

KMN Single-Row Corn Chopper Model MBJ

The model MBJ harvests corn as a forage crop at a rate of approximately 30 tons per hour when operating at a speed of 4.35 mph. Power is supplied by the power take-off shaft of a 30 h.p. or larger tractor. It is 8 feet long and weighs 860 pounds. A larger model, MB-37 is also available.

KMN Modern Farm Equipment, Inc.
12 Sullivan St.
Westwood, NJ 07675

Corn Combines

A corn combine is the same machine as a grain combine, but it has a different header and different screens. It picks, husks, and shells the

corn in one operation. Just as many large American-manufactured combines are interchangeable for wheat and corn, so too are many of the smaller combines discussed earlier in this chapter.

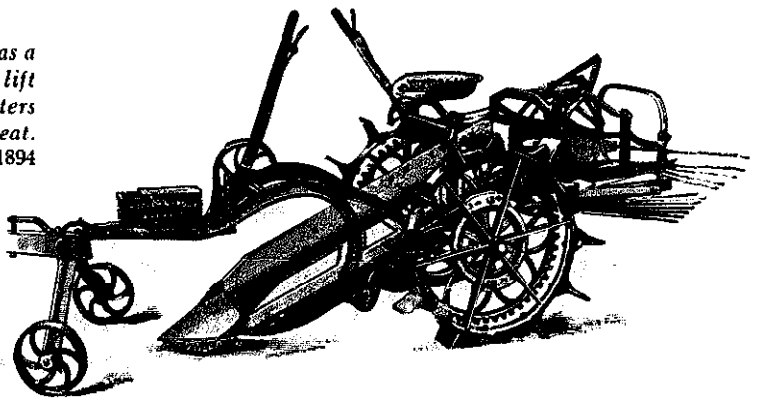
ROOT CROPS

Root crops like potatoes, cassava, and sweet potatoes, which form their fruits under the soil, are usually grown in small acreages; so the high cost of specialized harvesting equipment is not justified by the amount of labor saved or the increase in output. However, a number of universal root-harvesting machines have been developed which can be used for a number of similar crops with only minor modifications to some of the parts. This way, the capital cost of the harvesting machine can be distributed over a number of crops, a particular advantage for the diversified organic farm.

The simplest and oldest implement for harvesting potatoes, still in use for small-scale work, is the potato-raising plow. A modified moldboard digger raises the potatoes from the ground onto prongs which sift the tubers from the soil.

The elevator-digger for potatoes carries a metal elevator chain composed of parallel links, which run on agitator sprockets behind the lifting share. The soil is shaken through the links of the chain web, and the potatoes are delivered partially clean at the rear of the machine in a narrow row ready to be gathered by hand. Taking the process one step further, some harvesters have another set of chains working either behind or at right angles to the first one to deliver the potatoes to an accompanying cart.

The most difficult operation in potato harvesting is the separation of stones and clods which are about the same size as the potatoes. It is necessary to follow harvesting with a step for separating the potatoes from the debris by hand. At this time, the potatoes are usually graded for size and quality.



This horse-drawn digger has a ground-driven conveyor to lift potatoes onto the shaking sifters behind the operator's seat. The Implement Age, 1894

SOURCES OF HARVESTING PLOWS

I.D.C.-Bornu Groundnut Lifter and I.T. Groundnut Lifter Plans

The I.D.C.-Bornu Groundnut Lifter was originally developed in a joint USAID/Ministry of Agriculture project at Maiduguri for the savanna area of northern Nigeria. This tool was later introduced by the I.D.C.-Zaria for manufacture by local blacksmiths, and it was more recently adapted for local manufacture at the I.T.D.G. Project at Magoye, Zambia. The lifters have no sifting tines but were designed specifically for groundnut raising (peanuts and legumes).

Intermediate Technology Publications, Ltd.*
9 King St.
London WC2E 8HN, England

Hert Digger

Digging five times faster than a hand tool,

* Intermediate Technology publications can be ordered from International Scholarly Book Service, Inc., Box 555, Forest Grove, Oregon 97116.

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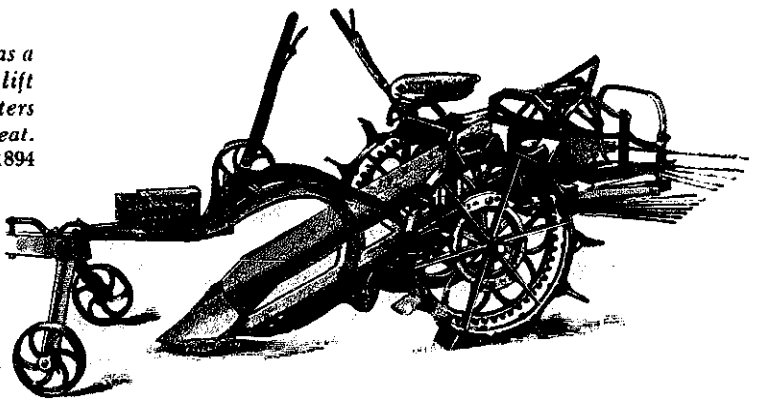
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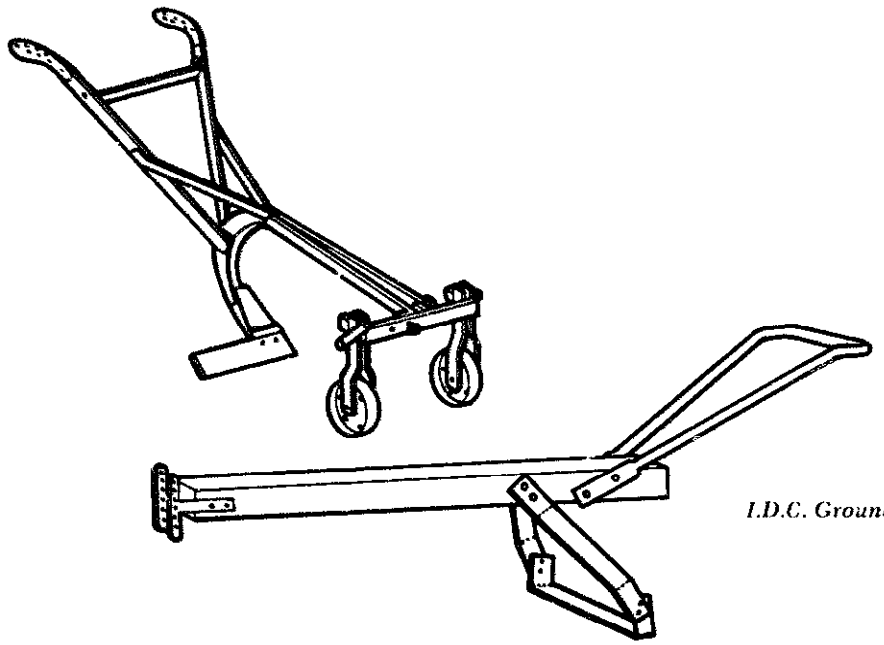
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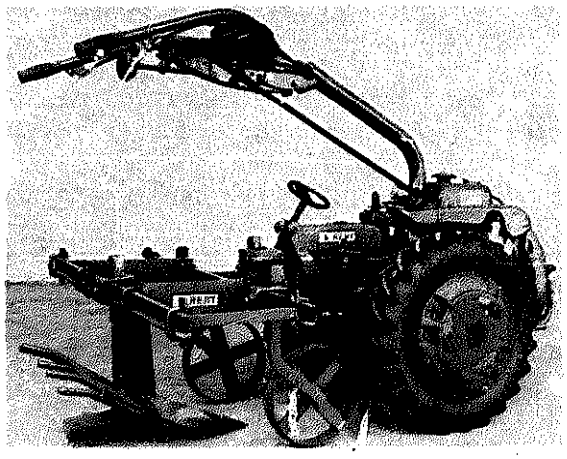
Hert Digger

Digging five times faster than a hand tool,

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I.D.C. Groundnut Lifters.



The Hertecant potato-raising plow, mounted on an Agria two-wheel tractor.
Willem Hertecant

this digger is attached to a multipurpose main body. Other attachments include a hoe and ridger. The digging element weighs 37.5 pounds, the forecarriage 55.2 pounds. There is a choice of a single or double handle, made to order.

W. Hertecant
9200 Kwatrecht
Wetteren, Belgium

AEBI Potato-Harvesting Attachment

With their model AM 75 two-wheel tractor, AEBI offers a potato digger with a longsifting provision for rooting out potatoes and leaving them piled on top of the soil in a neat row. It is adapted for operation on a 35-percent slope.

AEBI & Co. AG
CH-3400
Burgdorf, Switzerland



AEBI Potato Harvester
AEBI and Co.

Other Potato Diggers for 2-Wheel Tractors Are Made By:

AMC Equipments
Bienvillers 6211 Fonequevillers
Boite Postale 5, France

Bouyer
B.P. 23
Tomblaine 54510, France

Pasquali U.S.A.
Verona, WI 53592

W. Hertecant
9200 Kwatrecht
Wetteren, Belgium

Pasquali Macchine Agricole s.p.a.
Via Nuova, 30, Calenzano
Firenze 50041 FI 082, Italy

MECHANICAL POTATO PICKERS*

by A. A. Stone and Eric Patterson

Editor's note: This article describes some of the old-time tools of potato harvesting. Looking back is a way of looking ahead for small farmers who recognize the value of old tools and can put them to work in a modernized way.

Before many years, the job of picking potatoes will be entirely a machine operation. Hand labor has been eliminated in nearly all of the other operations necessary to potato growing, and machines are even now on the market that eliminate the laborious job of hand picking.

Two types of mechanical potato pickers were used at the New York State Institute of Applied Agriculture at Farmingdale in 1929. These were picking machines only and had no sorting or grading attachment. Each of these machines employs a different principle.

In one, the potatoes are carried upward on the picker-elevator and emptied into bags at the rear of the elevator. While passing up the elevator, men on both side platforms must discard the vines, trash, and stones to prevent them from being bagged with the potatoes. The successful operation of this machine requires thorough separation at the digger, so that the load falling on the picker-elevator is reasonably clean. For best results, it should be used with a power-driven digger having a seven-foot main elevator, and either the usual vine turner and shaker or an extension elevator in the rear of the main elevator.

The other type was used for digging the entire crop on the Institute farm. The trash and vines are carried directly over the rear of the picker-elevator and dropped to the ground. The potatoes are picked off the long elevator by hand and placed in small conveyors at either side of the rear platform. Each side conveyor delivers through a two-way chute, permitting four bags to be carried.

The digger-elevator delivers its load directly to the main elevator of the picker. No vine turner or extension elevator is used on the digger. It was found that having a man on the digger to throw off the heaviest part of the vines and trash greatly lessened the work of the men on the picker.

No attempt was made to keep accurate figures showing the labor-saving or timesaving value of the machine, as the chief interest was in testing it from a mechanical standpoint. Various observers agreed, however, that it reduced the time usually required by 30 to 50 percent. The use of the picker made continuous digging possible, whereas with handpicking methods, the digging proceeds so much faster than the picking that the digger is kept idle much of the time waiting for the pickers to catch up. Digging proceeded at the rate of about two hours per acre.

There was an indication that some potatoes were bruised in passing over the picker. It was difficult to determine just where this bruising occurred, but it seemed to be on the main elevator of

* Reprinted with permission from *Agricultural Engineering*, September 1930.



One of the first mechanical potato harvesters built, though obsolete for large farms, still satisfies the needs of today's small farmer.



The best way to find an old forgotten tool is to scour the countryside and rummage through the weeds.

the picker, as potatoes passing up this elevator would occasionally be jostled, due to uneven ground, and would roll down the elevator, striking the bottom with sufficient force to cause the bruising. It was also noted that quite a number of small potatoes were left on the ground. These were believed to have sifted through the links of the digger-elevator. This was not considered a serious fault, as many growers prefer to leave such small potatoes in the field.

A tractor with a slow forward speed is necessary to use this picker. First or low speed was found to give the best results. It was necessary to idle down the tractor motor considerably in order to reduce the forward speed sufficiently. Where a traction type of digger is used, this reduction in forward speed would, in ordinary years, cause poor separation at the digger, but this year it made little difference. Probably an engine-driven or a power take-off-driven digger would be better than a traction digger for use with a potato picker.

THE TINKERING FARMER

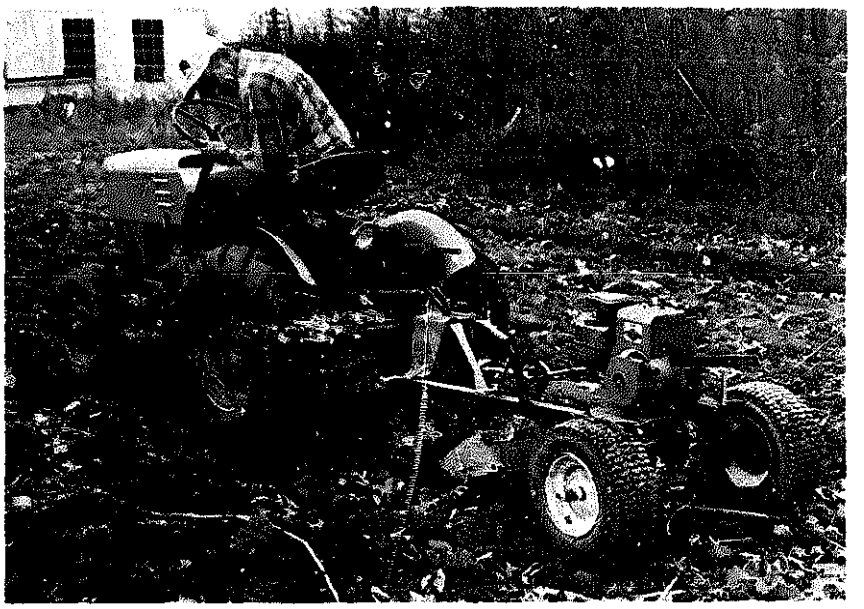
Moving ahead by studying the past, Curtis Johns of Upper Sandusky, Ohio has built himself a small potato digger and he hopes to go into production soon. He fashioned it after a traditional design from spare and older parts to custom fit a category 0 or 1 three-point hitch on a tractor with 14 or more horsepower.

Johns' family and his daughter's family plant four or five acres of potatoes each year for their own personal use and a few more for sale. Such a large project called for something more than a potato hook with which to harvest, so he designed his own harvester. Johns is a tinkerer of the first degree, and the digger was by no means his first project. He has turned an old horse-drawn planter into a two-row corn planter and adapted a rotary hoe to the three-point hitch of his garden tractor.

The front blade of the digger is 15 inches wide to get the whole mound of potatoes and skims along under the ground. Potatoes slide up a drag chain onto shaking tines which sift the soil away. Then the potatoes roll back behind the digger onto the ground. The escalating chain and vibrating tines are powered by an independent 5 horsepower gasoline engine mounted on the rear end of the digger.



Curtis Johns' homemade potato digger.

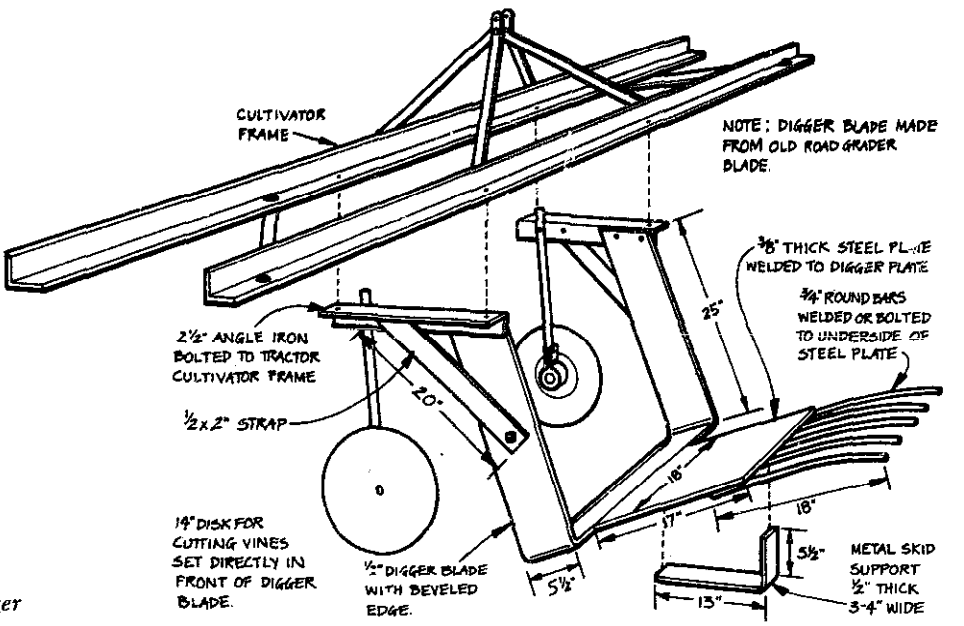


Johns' digger at work.

One prerequisite of the digger is that it be used with a slow-gear tractor, one with a creeper gear if possible. Johns uses an Economy tractor; he is a dealer. In its lowest gear, the digger will harvest 300 feet of potatoes in 15 minutes. He is thinking of attaching a catch pan to collect the potatoes but, says Johns, "I prefer to let them fall on the ground and dry a little. They'll keep a lot better in storage."

Texas Potato Digger

Angle iron, discarded coulters or discs, an old road grader blade, some round metal bars, a few scrap steel plates, and a few bolts are all the necessary parts for building this potato digger. It attaches to a three-point hydraulic lift. The design originated at the Texas Agricultural Extension Service of the Texas A & M University System.



Texas Potato Digger

NORTH AMERICAN SOURCES OF POTATO HARVESTERS

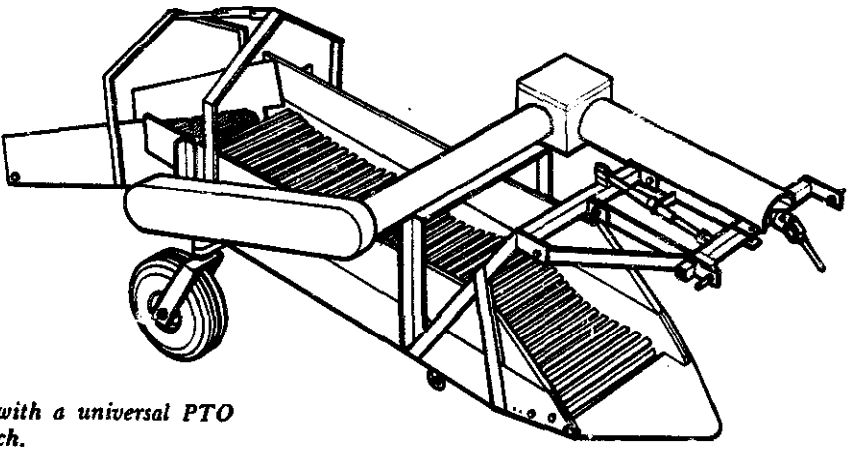
P & S Digger

One-row, two-row, and wide-row, tractor-mounted, sweet potato diggers are available from this company. Mounted from a three-point hydraulic lift system, the depth is easily adjusted from the operator's seat. No additional supporting or gauge wheels are necessary. The one-row harvester can be pulled by a 25 h.p. tractor. A 26-inch wide digging shovel and shaker chain are used to insure lifting and cleaning of all potatoes in the row. Harvesters for grading by hand labor are also available.

H.S. Shoemaker & Son
Rayville, LA 71269

Dahlman Small Root Crop Digger

Suggested for use with a 25 to 40 h.p. tractor, this small root crop digger is used for harvesting potatoes, onions, beets, rutabagas, turnips, parsnips, sweet potatoes, carrots, and other bulb roots.



The Dahlman Potato Digger with a universal PTO connection and three-point hitch.

Dahlman, Inc.
540 Broadway S, P.O. Box 504
Braham, MN 55006

INTERNATIONAL SOURCES OF POTATO HARVESTERS

Turnill Diggers

Both single- and double-row harvesters are available. The single-row harvester is fitted with a V-drawbar for operation with a lift bar between the tractor lower limbs and PTO drive, combined pneumatic depth wheels, disc coulters (scalloped) with screw adjustment for depth, and 16- by 4-inch heavy-duty wheels.

Root Harvesters Ltd.
Fengate
Peterborough PE1 5BD, U.K.

Hellas Potato Extractor

The Hellas harvester extracts potatoes from the ground without any injury or blockage and sifts soil away from the tubers as they are carried up an elevator. It works in sandy, rocky, hard, or soft soil. It measures 1.4 by 3 meters, weighs 400 kilograms, and will harvest a 1,000-meter plot in 20 minutes. It requires a 30 h.p. tractor to pull it.

Altermon S.A.
15 Messogion Str.
Athens 609, Greece

Elli Deidone M Sp D

This model is a towed potato harvester with double-floating sieve. It handles one row at a time, unloads from the side, and is mounted by a three-point hitch. Power take-off from a tractor is by means of a carden shaft. The digging depth is adjustable. The vibrating parts are mounted on sealed ball bearings.

Fratelli Deidone Macchine Agricole
C.C.I.A.N. 59212, Casella Postale 7
Villafranca Di Verona, Italy

Agromet 2610

This unit digs potatoes from two rows simultaneously, cleans them on the lath conveyors, and lays them down in a narrow strip running along its side. High-efficiency performance on level ground as well as on slopes recommends this machine for farmers who grow potatoes on medium and medium-heavy soils.. It is equipped with a hydraulic system which steers its wheels, while a suspension frame prevents skidding on slopes and insures precise steering control. The construction element is a transversal conveyor with rubber-coated laths, belt, and side screen. Its working width is 125 centimeters; potato ridge spacing is 63 centimeters, and the working depth is up to 25 centimeters. The digger has an output of 5 hectares per hour and a power requirement of 14 h.p. The KEP-2 model is for light or medium soils, digs two rows at one time, and requires 25 h.p. or more to operate.

Agromet Motorimport
Foreign Trade Enterprise
Warszawa, Przemystowa, Poland

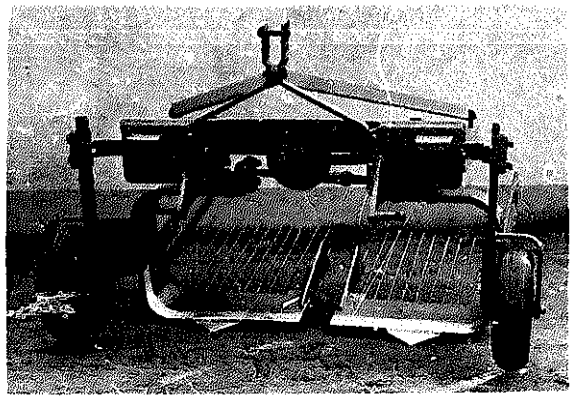
CeCoCo Potato Digger

This Potato Digger scoops up the buried potatoes with a digging blade. The mass of soil and potatoes is delivered to a traveling link elevator which is agitated up and down to sift soil through the links. A two-row type, powered by the PTO pulley of a 30 h.p. tractor, it has a capacity of 1.25 to 1.5 acres per hour and a working width of 1,240 millimeters.

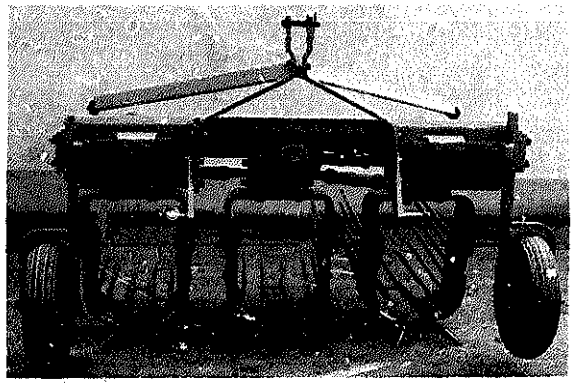
CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Hert Digger-Aligner Model PR-71

Designed for potatoes and sugar beets, the digger-aligner fits all tractors with a three-point linkage and a minimum of 15 h.p. It consists of a sturdy frame carrying the sieves which are actuated from the power take-off through connecting rods and link mechanisms. The unit handles easily on slopes of up to 18 percent. It digs and aligns two rows of potatoes at distances from 60 to 80 centimeters. A different set of sieves is necessary for sugar beets. Three rows of beets set at different distances will be dug and dropped together in one row.



Hert Digger-Aligner for Potatoes.
Willem Hertecant

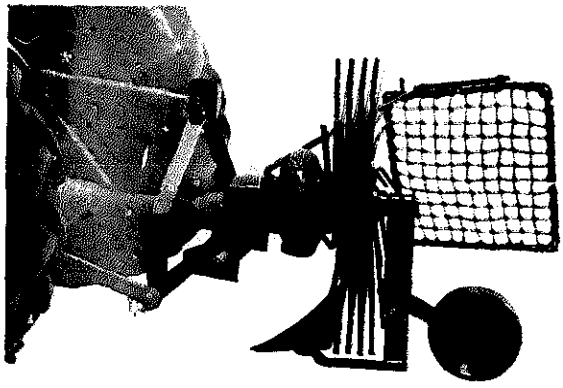


Hert Digger-Aligner for Sugar Beets.
Willem Hertecant

W. Hertecant
9200 Kwatrecht
Wetteren, Belgium

Champenois Potato Digger

The only design of its type seen as yet, this potato digger attaches to a tractor three-point hitch and power take-off shaft. A digging plate raises the potatoes from the ground and feeds them into a set of revolving tines. The tines flip the potatoes against a 1-inch soft mesh netting;



Champenois Potato Digger.
Champenois

the small stones and soil pass through, and potatoes drop in a line along the soil surface.

Champenois
Chamouilley
52170 Chevillon, France

HARVESTING NUTS

Anyone who owns several nut trees or has planted a small crop of groundnuts has no doubt been confronted with problems at harvest time. The equipment necessary for small enterprises simply is not readily available. Harvesting a nut crop may require hours of back-breaking labor to collect the nuts by hand or a substantial financial investment to purchase the large machinery designed for commercial ventures. We found only two devices which gather fallen nuts from under trees and spare the operator repeated bending over.

Stand-Up Pickup Pecan Gatherer

Designed to gather pecans and other nuts, this device has been in use since 1957. It is constructed of a spring-steel wire cage which can harvest nuts of many different sizes and permit the operator to remain in a standing position. Gathering occurs as the nuts are pressed between the wires of the cage, and when the wires return to their original position, the nuts are now contained within the cage. The nuts are released by catching the two punch-outs on the rim of a bucket and pushing forward. Should the wires wear out, replacements are available.

The Ray Griffith Co., Inc.
705 Sumrall Rd.
Columbia, MS 39429

Pecan Picker-Up-Er

Originally designed for pecan harvesting, this simple implement can be used to pick up most kinds of fallen nuts from the ground. The device is composed of a wire spring formed into a semicircle, with a long handle. Nuts are collected by pressing the spring onto the nut—the wires separate, then return to their normal position with the nuts inside. To remove the nuts, the tool is simply held upside down over a container.

H & K Co.
715 Camden St.
San Antonio, TX 78215



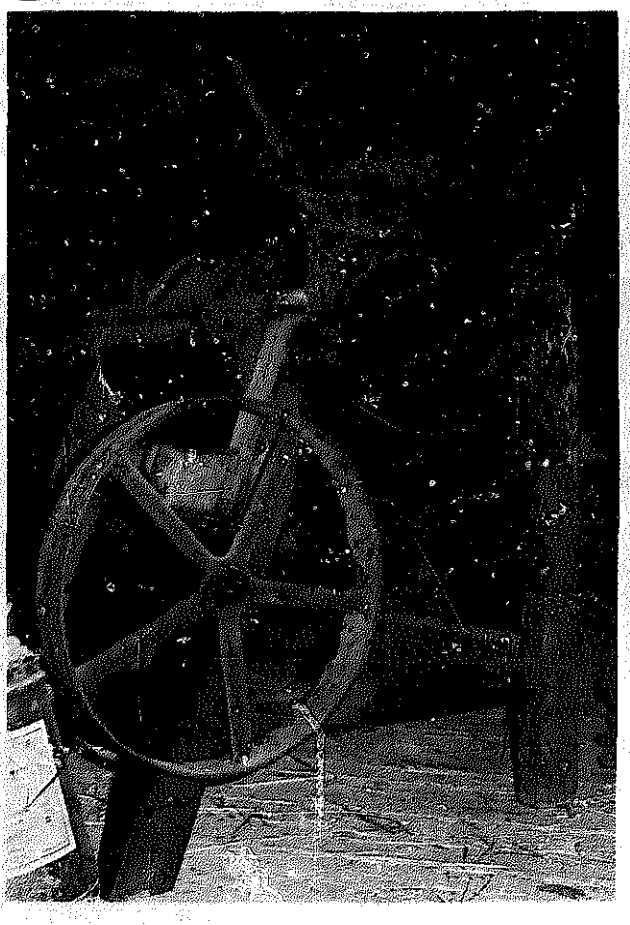
H and K Picker-Up-Er
H and K Co.

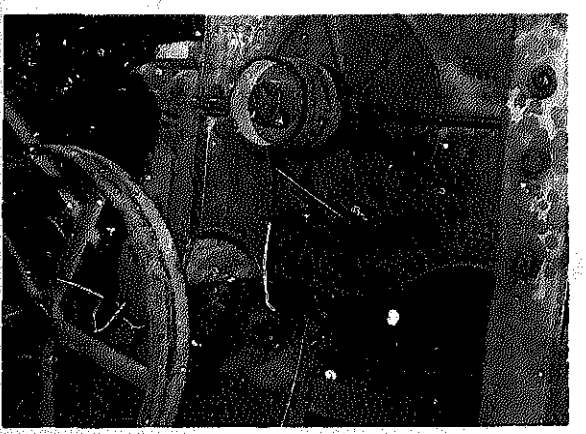
-7- Cleaning Grains and Seeds

After harvest, a grain, bean, or seed crop may need to be broken away from its stalk, separated from the inedible protective chaff, and cleaned of dust, dirt, and pebbles before it is ready for human consumption. The operations for completing these tasks are called threshing, winnowing, and cleaning. Grain to be used as seed proceeds one step further, through a separator. This process provides a product of uniform size and removes any misshapen seed which might not germinate.

In most parts of the world except North America, small-scale machinery for threshing, winnowing, and cleaning is available in abundance, especially in the Far Eastern countries. Until recently, a North American farmer had only three choices—using a primitive flail and hand winnower, antiques, or expensive combine harvesters which combine the harvesting and processing operations into one. We have uncovered numerous sources of tools to fill this gap, but most of them are foreign to the North American market. We can offer three points of encouragement, however:

1) Most manufacturers are willing to export to North America.
2) Many North American manufacturers have





The inscription "June 19, 1877. Try Me Once" should perhaps read "Try Me Once Again," as the value of old farm equipment is realized anew.

An old stationary thresher belt-driven from a pulley on the tractor power-take-off shaft.



An old stationary thresher in the field.
Dr. B. N. Ghosh

shown an interest in starting production on new tools and implements, given a market for their products.

3) The techniques are simple, and enough build-it-yourself plans are available for you to satisfy your own needs.

HAND THRESHING

The simplest method of hand threshing involves spreading a large, clean cloth (an old bedsheet is fine) on the floor of a barn or garage, laying a bundle of wheat on the sheet and beating it with an old rake, broom handle, or other appropriate club. The wheat heads do not have to be struck hard, for the grain will shatter out quite easily onto the sheet.

As another alternative, grain can be dislodged by allowing farm horses or bullocks to trample on unthreshed stalks. Threshing by trampling, however, is neither particularly efficient nor very hygienic, because of the possible contamination of grain from animal excreta.

In hand threshing, not every grain will fall out of the seed heads. But it need not go to waste. The bundles already flailed can be given to the chickens; they will pick out any grains missed, and the straw becomes their bedding. Each bundle of wheat will have a cup or two of grain in it. After several bundles are flailed, the corners of the sheet are pulled together, and the grain, chaff, and bits of straw are dumped into a bucket.

There are other alternatives to harvesting and threshing by hand, even for small-plot growers. Threshers and hullers are still very much used by the seed-processing trade, of course, but these machines are usually too expensive to be practical for homesteaders. But shredders will do a crude job of threshing grain in addition to performing their usual functions. Modifications, such as taking out every other blade or removing the screen completely, might improve the quality of the shredder's threshing work. The motor can be geared down so it will run the shredder more slowly. Wheat can even be threshed with a lawn mower, so long as a board is placed to one side to block the grain from being scattered too far by the blade.

ANIMAL-DRAWN THRESHERS

A fairly recent development in threshing by animal power that is much faster than trampling, is the Olpad thresher. It consists of some 20 serrated or ribbed metal discs arranged in three

rows on a metal frame which is pulled by a pair of bullocks. A wooden beam or a suitable length of chain or rope can be used to hitch the animals to the frame. The output of the thresher is estimated to be four to five times that of a pair of bullocks threshing by trampling. Solid, cylindrical rollers and spiked wheel models are available, and ordinary animal-drawn disc harrows can also be used for this operation.

SOURCES OF ANIMAL-DRAWN ROLLER THRESHERS

Stone-Threshing Roller

This roller is tapered so that it can easily be pulled round in circles over the crop by the animals.

Dandekar Brothers
Engineers & Founders
Sangli, Maharashtra, India

Olpad Thresher

This unit has serrated discs 450 millimeters (18 inches) in diameter, and an angle iron frame. Discs are mounted on a steel shaft and cast-iron spools keep them in position. A seat with a back, footrests, and back and front guards are provided for the operator's safety. An extra raking attachment can be fitted for stirring straw during the threshing operation. This thresher is available in 20-, 14-, 11-, and 8-inch disc sizes.

Cossul & Co. Pvt. Ltd.
Industrial Area, Fazalgunj
Kanpur, India



Cossul Bullock-Driven Olpad Thresher
Cossul & Co.

Olpad Thresher

This model has 14 discs and transport wheels.

Rajasthan State Agro Industries Corp., Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006, Rajasthan, India

The Rasulia Bladed Roller Thresher Plans

This thresher is apparently suitable for all types of corn and similar crops, and could be made and used anywhere where bullocks are available and suitable local craftsmen and materials can be found. It has proved to be 60 percent more efficient than the traditional Indian method of using bullocks to trample the harvested crop.

Intermediate Technology Publications, Ltd.
9 King St.
London WC2E 8HN, England

TREADLE THRESHERS

Treadle-operated rice threshers are widely used in the Far East. Bunches of straw are held against a revolving drum and the grain is combed out by wire loop teeth. These machines are generally suitable for rice only and not for crops such as wheat, which require a more violent threshing action.



Operating a treadle thresher by holding bunches of straw against a revolving drum.

A FOOT-POWERED THRESHER FOR RICE, SORGHUM, OATS, AND OTHER SMALL GRAINS

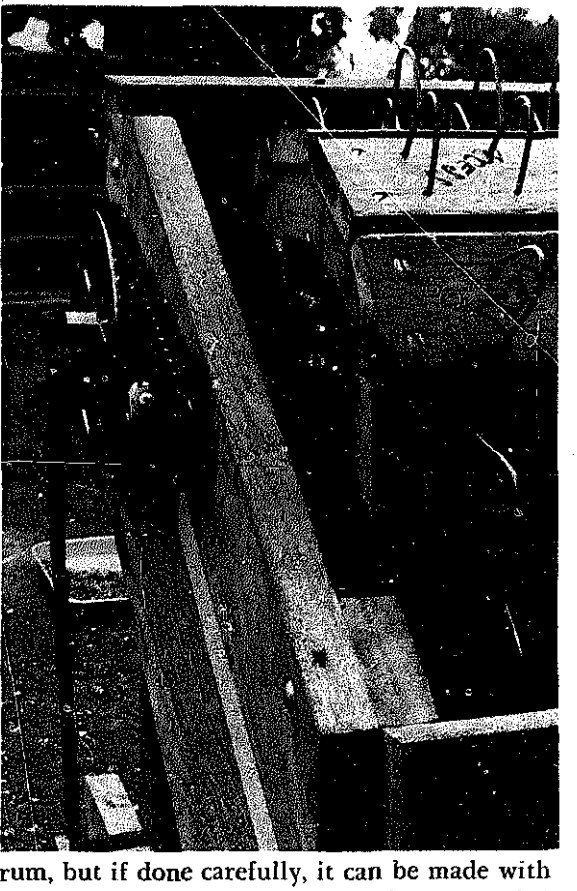
by B. David Williams, Jr.

This type of foot-powered thresher is not new. Until more advanced mechanization became widespread in Japan and Taiwan, similar machines were found extensively on small farms in those countries.

Substituting bicycle sprockets and chains for the gear system provides a simple answer to the problem of gears. Bearings from the bicycle pedal shaft are also easily obtained and are adequate for both the drum and the large sprocket shaft. The only sophisticated tools needed to build this thresher are an electric welder and a drill press. Most of the operations can be done with simple hand tools.



Building plans are available for this treadle-powered thresher.
S.P.A.T.F.



Bicycle sprockets and chain replace a complicated gear system. Simple wire loops on the threshing drum knock grain from the stalks as the drum revolves.
S.P.A.T.F.

The most difficult part of the construction is the drum, but if done carefully, it can be made with simple tools. Balance is important, but not overly critical, as the drum spins at only 250 to 300 revolutions per minute. The wire loops on the drum are the teeth which strike the grain from the stalks.

* Reprinted with permission from *Appropriate Technology*, vol. 2 no. 2.



The thresher in operation—the cloth hood keeps threshed grain confined, and the drop cloth collects the kernels. S.P.A.T.F.

This machine does not separate the chaff from the good grain. As in threshing by hand, the grain must still be winnowed. But the machine does speed up the threshing and is also effective on some tough grains such as sorghum, which often defies hand threshing.

Threshing is done by holding a bundle of unthreshed grain firmly in your hands, beating and twisting the bundle lightly against the drum (which revolves away from you), and throwing the bundle of threshed straw aside. The grains fall down onto a canvas or plastic sheet which is placed under the thresher.

The work of cleaning the grain will be a lot easier if you first put the threshed grain into a box with ½-inch wire mesh screen on top. This will remove many of the broken stems and longer trash.

Those who want a simple, engine-driven thresher can build a similar machine, but with a wider drum of 36 inches, a stronger shaft of ¾ inch, and a large pulley on one side. A three to five horsepower engine will be sufficient, and in this case, approximately 400 revolutions per minute would be best.

A 24-page fully illustrated booklet, "Do-it-Yourself Foot-Operated Thresher Plans," for construction, assembly, and maintenance is available from:

S.P.A.T.F., Office of Village Development
P.O. Box 6937
Boroko, Papua, New Guinea

A condensed version is offered by:
Intermediate Technology Publications, Ltd.
9 King St.
London WC2E 8HN, England

SOURCES OF TREADLE-POWERED THRESHERS

Peanut Thresher Plans

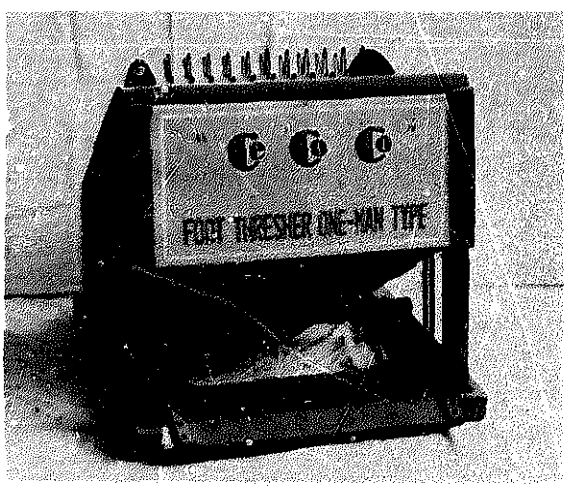
Five pages of fully dimensioned, illustrative plans with complete assembly instructions for a treadle-powered or bicycle-powered peanut thresher are available from:

Cumberland General Store
Rt. 3
Crossville, TN 38555

CeCoCo Light Foot Thresher

This machine separates the grain from paddy sheaths by eliminating the mud, sand, stone, pieces of metal, and other foreign substances contained in the paddy. It is portable and conveniently used in the paddy field at the spot where the crop is harvested. Rotary motion is caused by stepping on the pedal; revolution rate is increased by gears, turning the threshing drum at any required speed. Crops are threshed by placing them against the toothed revolving drum.

The number of pedal strokes ranges from 90 to 100 per minute; the approximate drum speed is 450 rpm. The thresher is capable of threshing paddy at 115 kilograms per hour. It measures 15 cubic feet. Net weight: 50 kilograms: packed weight: approximately 90 kilograms.

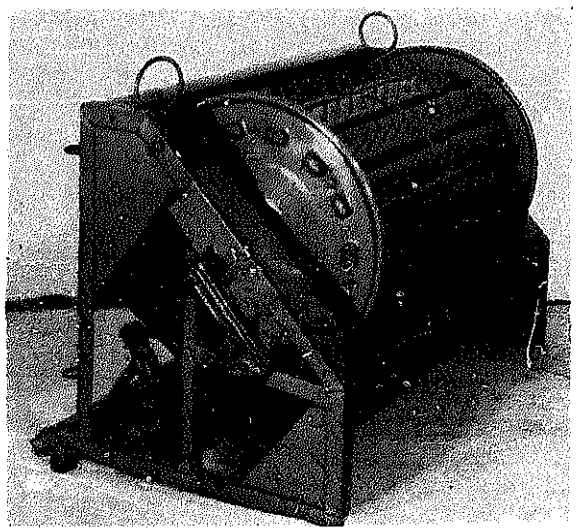


CeCoCo Treadie Thresher

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Pedal Thresher

This two-man pedal threshing machine can be used for either rice or wheat. Dimensions are 41 by 27 by 26½ inches. Weight: 62 kilograms.



Tien Chien Pedal Thresher
Tien Chien Enterprises

The thresher has a capacity of 500 kilograms per hour.

Tien Chien Enterprises Co., Ltd.
P.O. Box 20-18 Taichung
Taiwan R.O.C.

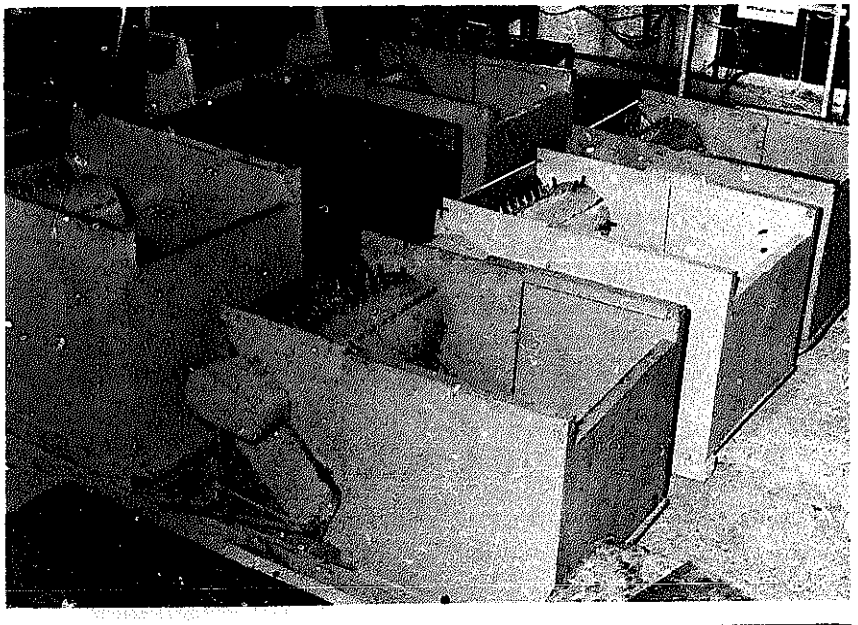
Pedal Thresher Model TAT-10

This unit can be operated by one or two people. Threshed grain is scattered on the ground so a pickup nylon net or grain box is recommended and is available as optional equipment. Dimensions are 75 by 100 by 70 centimeters. Weight: 61 kilograms. It is also available with a 3 h.p. gasoline motor.

China Agricultural Machinery Co., Ltd.
17 Nanking Rd. East, 1st Sec.
Taipei, Taiwan R.O.C.

Technology Consultancy Center Thesher

This pedal-powered rice and millet thresher is only in the prototype stage. The Technology Consultancy Center is also working on the development of prototype bullock and donkey carts, a winnower for pressing rice oil (60 percent efficiency), and a bellows pump.



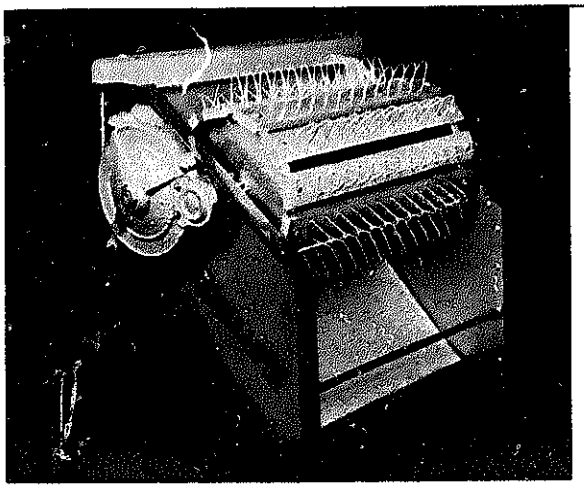
Prototype pedal threshers at the Technology Consultancy Center.
Technology Consultancy Center

Technology Consultancy Center
University of Science and Technology
University Post Office, Kumasi
Ghana, West Africa

More Treadle-Power Threshers

American Spring & Pressing Works Pvt., Ltd.
P.O. Box 7602
Malad, Bombay 400 064, India

Cossul and Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India



Cossul Treadle Power Thresher
Cossul and Co.

A.P. Rodriquez Agro Industrial Machineries
Bitas
Cabantuan City, Philippines

POWER-OPERATED THRESHERS

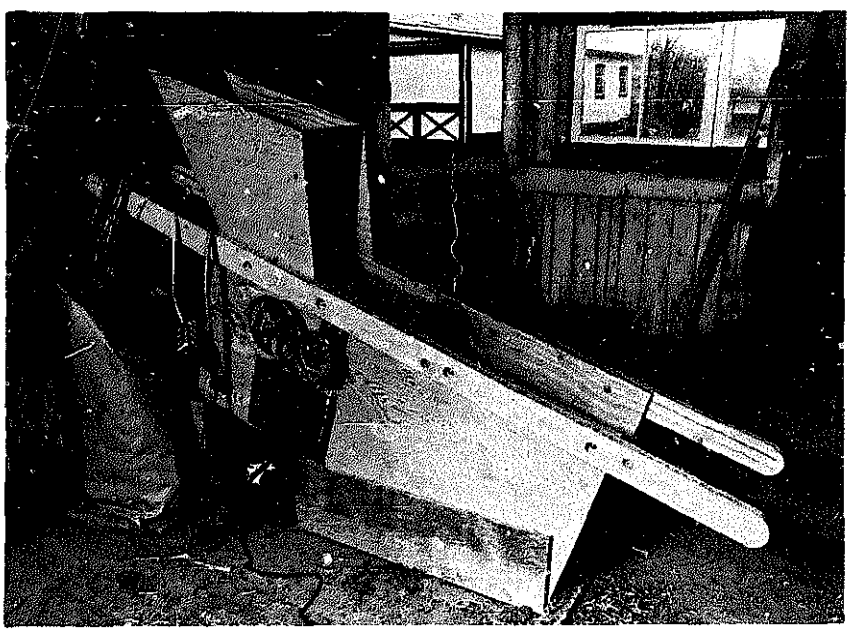
In a power thresher, the separation of grain from its stalk is carried out by passing the crop between a revolving drum and a stationary concave. The impact of the drum striking the grain against the concave beats the grain from the ears. In the shape of a half-cylinder, the concave forms a cradle below the threshing drum. It is either solid or grated and is always made of very strong wrought iron or heavy steel.

The revolving drum or cylinder carries a number of steel spikes or fine rasp bars as threshing teeth. Spiked teeth are often found in combines and threshers designed for rice processing. Because most small threshers are designed in rice-producing countries, they generally come equipped with spike-tooth drums which are not as efficient for threshing wheat. Rasp bar drums with fine-tooth spacings on the threshing bar are generally preferred for separating finer seeds from chaff. The threshing body of most modern combines comes equipped with a rasp bar, but both types of cylinders are usually available interchangeably.

Balance is an important factor. A thresher should be set on level ground with the drum carefully balanced to avoid vibration. If it's not level, the movement of grain across the width of the drum is uneven and threshing efficiency is impaired. The gap between the threshing drum and the concave is adjustable, depending upon the grain to be threshed. If the gap is too wide, the grain passes out of the machine with the straw, while too close a setting will break or bruise the grains.

Some small machines operate on a principle similar to the treadle rice threshers, with the crop being held against the revolving drum. But generally the whole crop is passed through the thresher. Spike-tooth drums are found particularly in Asia, where they are favored because they produce thoroughly crushed straw, or bhusa, which is fed to animals.

Threshers without cleaning equipment are often favored by small farmers because they combine high rates of threshing with low power requirements. They can often be driven from the power take-off (PTO) shaft of a two-wheeled tractor or by a gasoline or electric engine. Winnowing is done at the farmstead during slack periods. At this point, threshing is complete.



Plans for this build-it-yourself thresher may be obtained by writing to:
Organic Gardening
Readers' Service
33 E. Minor St.
Emmaus, PA 18049
Enclose a stamped, self-addressed envelope.

THRESHING SEED CROPS

by Rob Johnston

If the crop is small, we often use a homemade flail. For larger crops, we use a Universal Thresher made in Japan by CeCoCo (Central Commercial Company), P.O. Box 8, Ibaraki City, Osaka Pref. 567 Japan. While it is not built as ruggedly as a comparable domestically made machine, it gets the job done satisfactorily and costs a great deal less.

If you don't want to spend $1,000 for a thresher, which is what we paid for ours in 1974, the old models which still exist in this country are worthwhile, if they are in decent condition. In our area, the cost is between $200 and $500. These are usually large machines, powered by a gasoline motor or tractor power take-off with a flat belt. It is possible, however, to mount wheels on an old



Seedsman Rob Johnston threshing soybeans with his CeCoCo Universal Thresher from Japan.
Rob Johnston

thresher so the machine can be towed into the field for on-the-spot threshing. On the other hand, our CeCoCo thresher is small, weighing about 250 pounds, and can be carried short distances by two determined people. We went to a small bother of putting removable (bolted) wheels on one end, which aid in towing. This portable nature is a real plus for the Japanese machine.

The new American-made threshers are rather small units usually trailer-mounted and designed to thresh experimental plots in breeding and testing projects.

Catalogs which list such equipment include:

Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204

Seedburo Equipment Co.
1022 West Jackson Blvd.
Chicago, IL 60607

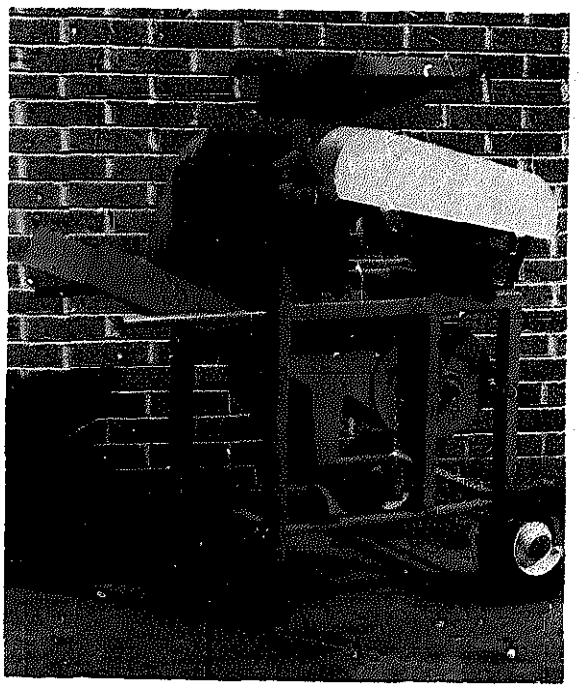
NASCO
Ft. Atkinson
WI 53538

NORTH AMERICAN SOURCES OF POWER THRESHERS

VITA Thresher Plans

Volunteers in Technical Assistance (VITA) publishes a number of technical bulletins in response to requests for technical help from organizations and individuals in developing countries. VITA plans include a peanut (groundnut) thresher, soybean thresher, and Godavari rice thresher, as well as a set of guidelines for portable threshers. A complete listing of publications is available from:

VITA
3706 Rhode Island Ave.
Mt. Rainier, MD 20822



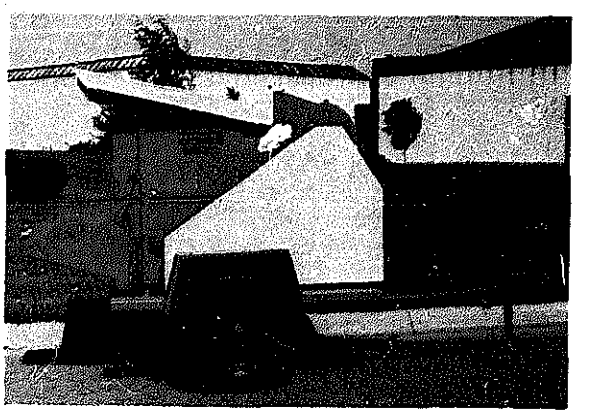
14-inch Plot Thresher
K.E.M. Corp.

14-inch Plot Thresher

The Seedburo plot thresher has a 14-inch wide peg-tooth cylinder and is completely self-cleaning. A straw puller is used to slow the material thrown from the cylinder and to meter it evenly into an air blast. Interchangeable screens are placed at the bottom of the air chute to further clean the sample. This thresher has a rasp bar cylinder with 52 teeth, and is mounted on wheels to be moved by hand. It measures 30 by 30 by 20 inches, weighs 200 pounds and is powered by a 3 h.p. gasoline motor (a ¾ h.p. electric motor is optional).

18-inch Bundle Thresher

This thresher is built with a coil spring axle for towing behind a vehicle. It is fully adjustable for small seeds and grains, including soybeans, and has 14-inch diameter cylinders, with eight rasp bars per cylinder. Two fans are used to assist in complete separation. It is powered by a 7.5 h.p. gasoline engine with a hand clutch, fully guarded for safe operation.



18-inch Bundle Thresher
K.E.M. Corp.

Both threshers are available from:

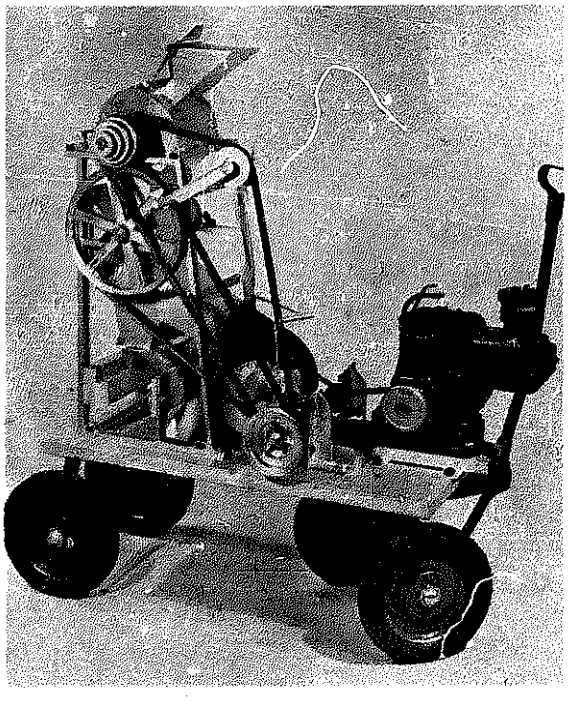
Chain Mfg. Co.
112 N. Kansas Ave.
Haven, KS 67543

K.E.M. Corporation
Box 471
Haven, KS 67543

Seedburo Equipment Co.
1022 W. Jackson Blvd.
Chicago, IL 60606

Small Bundle Plant and Head Thresher

A medium-sized, self-cleaning thresher, this model is suitable for efficiently threshing and air-cleaning single plants, small bundles (heads only) of cereal or grain crops, some types of legumes, and other crops for both yield and purity research experiments. Two styles of cylinders and concaves are available: overshot spiked-type (round or square, depending on the grain to be harvested) or overshot rasping bar-type. The thresher also comes with both styles of cylinders and concaves that are interchangeable on the same machine. It has a self-cleaning metering wheel, removable seed catch pan with recleaning screens, and an air blower. Its heavy-gauge metal housing is mounted on a channel iron frame with rubber-tired wheels and hand truck handles for easy handling. The thresher is approximately 34 inches long, 25 inches wide and 40 inches high. Weight: 190 pounds. Supplied with electric motor or gasoline engine.



Small Bundle Plant and Head Thresher with gasoline engine.
Allan Machine Co.



Small Bundle Plant and Head Thresher with electric motor.
Allan Machine Co.

Large Vogel Nursery Plot Thresher

Vogel plot threshers are one of the most popular makes because they self-clean completely in 8 seconds. The 20-inch-wide cylinder is the overshot type with spiked teeth or optionally equipped with rubber rub bars. The cylinder is fed directly from the feeding pan. A straw puller slows the flow of material from the cylinder and meters it to the shaker pan. A fan removes the straw and chaff from the grain as the threshed material passes over a tail rake. The seed is caught in buckets at the side of the machine. Power is supplied by a 9 h.p. gasoline engine. Approximate overall dimensions: 8 feet



Large Vogel Nursery Plot Thresher
Allan Machine Co.

long, 7 feet high, 40 inches wide. Weight: 1,350 pounds. This thresher has an all-metal construction, except for wooden fan blades and operator's platform.

Small Vogel Thresher

The Vogel head thresher is of the same basic design as the 20-inch Vogel thresher but without the shaker pan. The cylinder is 6 inches wide and is available with spike-teeth or rubber rub bars. Heads only are passed through the cylinder. Straw passed through the cylinder will not be removed from the sample if the straw pieces are heavier than the seed, as is often the case with forage. The thresher is self-cleaning within 3 seconds. It is powered by a ½ h.p. electric motor. Constructed of heavy-gauge metal, it is mounted on a coaster wagon truck for portability. Dimensions, including truck, are 15 by 38 by 46 inches high.

All-Purpose Nursery Plot Thresher

The Allan all-purpose thresher is used to thresh, separate, and clean samples of soybeans, wheat, oats, barley, flax, grasses, and other similar seed without loss. Construction is such that it may be easily inspected and cleaned between samples to prevent cross-contamination. Simple mechanical features permit fast adjustment of the cylinder blowers and shaker sieves to meet varying conditions of crops being threshed.

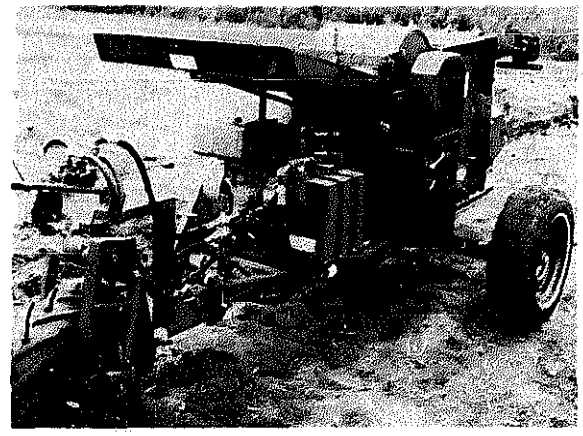
Standard equipment is an eight-bar, all-metal, rasp bar cylinder, five-bar adjustable concave, beater and straw puller, shaker pan with interchangeable no-choke sieves, adjustable catch pan, and two cleaning fans. A belt variator gives infinitely variable belt speeds to 2,000 rpm without affecting the speed of the shakers and blowers. Optional equipment includes rubber-faced rub bars.

The above threshers are available from:
ALMACO, Allan Machine Co.
P.O. Box 112
Ames, IA 50010

Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204

Low-Profile Plot Thresher

Constructed with an eight-bar rasp bar cylinder and underslung grated concave, the low-profile thresher is hand fed from ground level. The stationary, towable machine was developed exclusively for threshing small and medium test plots of legumes, cereals, forages, and other



This low-profile plot thresher has a hydrauiically operated unit for moving it as operators thresh row after row.
Allan Machine Co.

special crops. It comes with a galvanized metal shaker pan with choice of interchangeable no-choke sieves. With a 7 or 9 h.p. gasoline engine, the unit measures 113 by 40 by 57 inches and weighs 1,250 pounds.

LPT Stationary Thresher

Available in three types of overshot cylinders and concaves, each of which is interchangeable, the thresher will efficiently thresh a wide range of crops from small test plots up to ⅓ acre or larger in size. Cereal grains such as wheat, oats, barley, and sorghums; legumes including soybeans, cowpeas, and field beans; and forage crops such as grasses and sunflowers have been threshed without material loss of seed.

Its simple mechanical features permit easy changes of cylinders and concaves, no-choke sieves, varying cylinder speed, air blower, and seed catch pan to meet varying conditions for each crop being harvested.

Power to operate the standard-equipped thresher is provided by a 9 h.p., single-cylinder, four-cycle, air-cooled, gasoline engine with a rope-pull starter and hand-operated clutch take-off assembly.

The thresher, completely equipped, weighs approximately 1,375 pounds and measures 9 feet long, 5 feet wide, and 5 feet high. It is light enough to be moved easily by workers in the field or towed behind a car, truck, or tractor from one area to another.



Researchers feed sheaves into the ALMACO-LPT Stationary Plot Thresher.
Allan Machine Co.

Both threshers are available from:
ALMACO, Allan Machine Co.
P.O. Box 112
Ames, IA 50010

Single-Head Plot Thresher

Single head selections can be easily threshed in this single-head plot thresher. A ribbed rubber roller threshes the head by a crushing action against a spring-loaded rough rubber concave. The concave is hinged to allow the roller and concave to self-clean. A fan is built into the bottom of the thresher to blow out the chaff. The cleaned sample is collected in a small drawer.

L.A. Mennie
1029 Manahan Ave.
Winnipeg 19, Manitoba, Canada

Single-Head Thresher

Single heads or the product of short rows are threshed with this machine. It is self-cleaning, enabling a large number of single heads or small lots to be threshed and cleaned rapidly. The heads are pushed through a funnel-shaped chute to a peg-tooth cylinder. The straw is not passed through. Chaff is thrown into the chaff receiver by the cylinder air blast. The cleaned sample is collected in a drawer at the base.

Bridge & Tank Western, Ltd.
Winnipeg 2
Manitoba, Canada

Kemp Stationary Plot Thresher

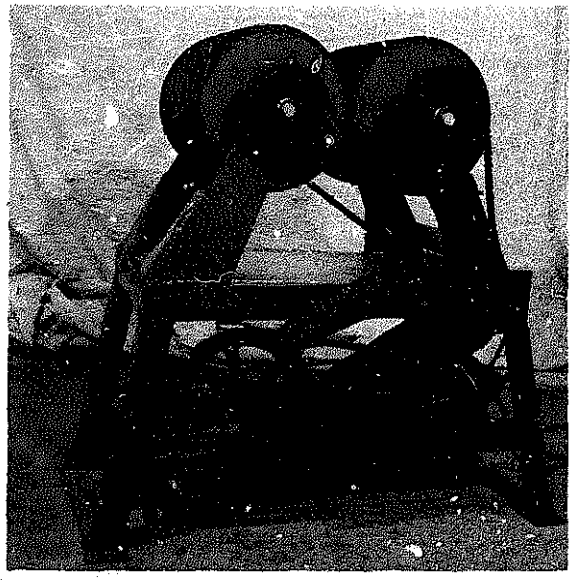
The Kemp stationary plot thresher has a spike-tooth cylinder that is 10 inches wide, with a 10-inch diameter base and a 7-foot long separating deck. The openings in the deck are varied in size to act as both a sieve and straw walker. Two blowers are used for cleaning. Unthreshed heads are delivered to a tailings drawer to be passed through the cylinder a

second time. The thresher can be used for threshing many crops including clover and forage crops. Peas and beans are threshed by operating the cylinder in reverse.

Bridge & Tank Western, Ltd.
Winnipeg 2
Manitoba, Canada

Roller Thresher

Plant material contained in cotton bags can be threshed by passing the bags through the rollers of this thresher a number of times. Mixing and seed loss are eliminated but the material must be cleaned in a separate cleaning device. The rubber-covered rolls are 14 inches in diameter, and contrarotate differentially at speeds of 50 and 68 rpm.



Roller Thresher
Agriculture Canada

Machine Services and Repair
47 Landsdowne Ave.
Winnipeg 4, Manitoba, Canada

Swanson Plot Thresher

Developed to thresh a wide variety of crops, the Swanson plot thresher has a low profile for easy operation and inspection. A special air device gives precise air adjustments for efficient separation. The 18-inch-wide cylinder and concave are built to close tolerances to eliminate lodging of seeds within the thresher. The cylinder has a speed range from 450 to 900 rpm.

Swanson Machine Co.
24-26 E. Columbia Ave.
Champaign, IL 61820

Harmond-type Plot Thresher

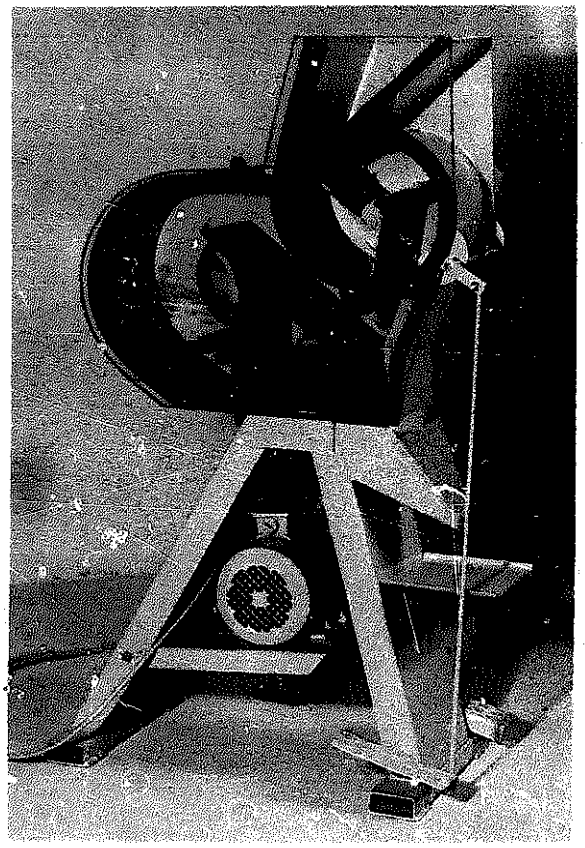
The Harmond-type Plot Thresher has a rubber rasp bar overshot cylinder with a speed control and an rpm indicator. A feeder-beater is used to present the material to the cylinder. Cleaning is by air-assisted sieve action using an adjustable sieve. The thresher has been used on a range of materials from bent grass to pistachio nuts. The capacity is 30 pounds per minute of wheat straw and 10 to 20 pounds per minute of grass straw.

Mater Machine Works
Box 410
Corvallis, OR 97330

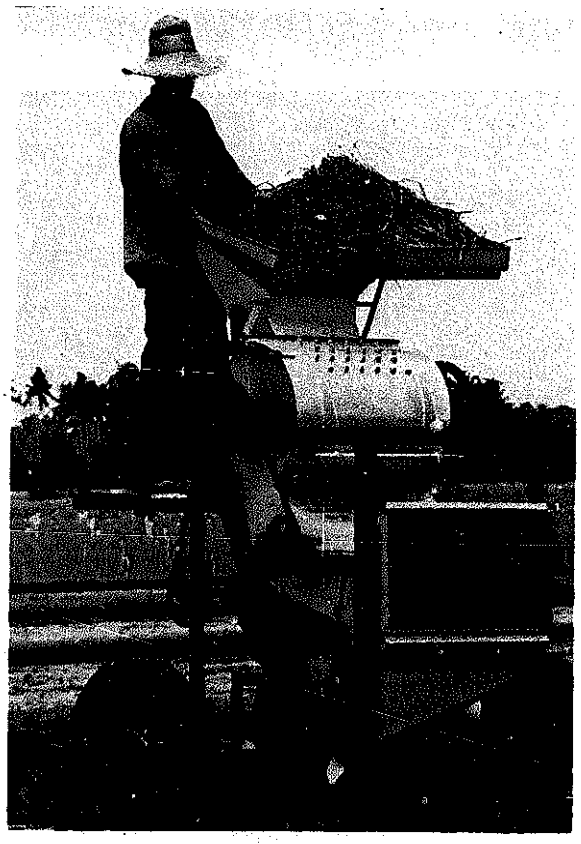


Labour-Ear Thresher Walter & Wintersteiger

Adapted from U.S. research models, these threshers were manufactured in the Philippines with the help of the International Rice Research Institute.



Vogel-type Head Thresher



Vogel-type Plot Thresher
International Rice Research Institute

INTERNATIONAL SOURCES OF POWER THRESHERS

Labour-Ear Thresher

The Labour-Ear thresher for single plants is unique in that it has a clear plastic side so the threshing and cleaning process can be observed. A hinged gate at the bottom of the cylinder keeps the material in the cylinder until threshing is completed. Chaff removal is by a suction fan with cleaned samples collected at an envelope chute. The unit is electrically powered and has variable speed pulleys for changing the cylinder speed. The thresher is claimed to be capable of threshing cereals, grasses, clover, and legumes.

F. Walter & H. W'ntersteiger K.G.
4910 Reid im Innkreiss
Frosch allgasse 19, Postfach 124
Dimmelstrasse, Austria

2 TD Thresher

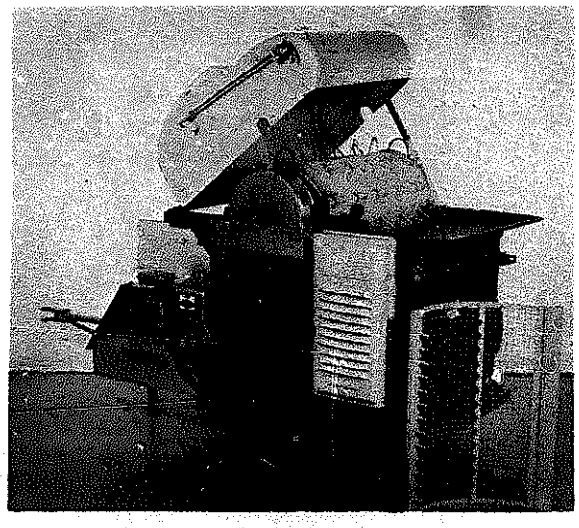
The 2 TD thresher has two threshing cylinders with adjustable concaves. The first cylinder does most of the threshing, while a second cylinder operates at a higher speed to shake and transport the straw during threshing. Cleaning is done by air currents. Straw and chaff are blown out at the top of a cyclone separator and the grain is collected at the bottom. The auxiliary air current necessary to blow the straw out of the top of the cyclone is shut off after each sample is threshed to drop any material held in the airstream. The thresher is powered by a 7 h.p. gasoline or electric motor.

Saat Und Erntetechnik
3440 Eschwege
Postfach 748, Germany

Garvie 14-inch Portable Thresher

This 14-inch-wide portable thresher is available with either a spike-tooth or rubber rub bar cylinder, and has a straw shaker and two clean-

ing sieves with an air fan. The machine is self-cleaning and can be inspected while it is running. It is powered by a 3 h.p. engine.



A typical Japanese thresher, similar to the treadle designs. This one is powered by a gasoline engine for a higher production capacity.
Agriculture Canada

Garvie Bench Threshers

Garvie bench threshers are available in 10- or 14-inch widths, with spike-tooth or rasp bar beaters and a variety of cleaning apparatus including a winnower, a cleaner (with up to three sieves or with a riddle case), and a fan.

R.G. Garvie & Sons
2 Canal Rd.
Aberdeen, Scotland

CeCoCo Portable Thresher

This is a lightweight, portable, and economical thresher suitable for small-scale rice and wheat growers. The all-metal construction unit is equipped with a 1.5 h.p. gasoline engine. It delivers unbroken grain at a capacity of 180 kilograms per hour.

CeCoCo Self-feeding Power Thresher

The CeCoCo Self-feeding Thresher is made for the purpose of threshing rice or wheat which is reaped as full stalks, gathered, and bound in sheaves. Paddy stalks to be threshed are placed on a feed table attached to the machine and are inserted continuously by hand in small quantities into the feeding end of the rotating chain. Inserted paddy straws are threshed while being shifted by the moving chain under the rotating threshing drum.

SPECIFICATIONS OF CECOCO SELF-FEED POWER THRESHER

Type	Capacity in paddy/hour	Power Required	Rpm		Dimension in mm			Net Weight	Gross Weight	Shipping Measurement
			Rice	Wheat	Height	Width	Length			
No. 1	500-1,000 kg	3-4 h.p.	570	670	1,380	1,010	1,350	150 kg	295 kg	60 cu. ft.
No. 2	400- 800 kg	3-4 h.p.	570	670	1,380	922	1,350	115 kg	255 kg	57 cu. ft.
No. 3	300- 600 kg	2-3 h.p.	570	670	1,374	842	1,350	90 kg	220 kg	54 cu. ft.

SPECIFICATIONS OF CECOCO POWER THRESHERS

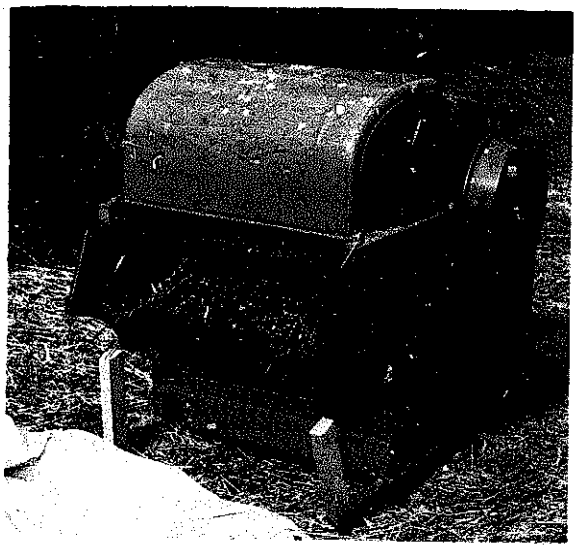
Type	Capacity in paddy/hour	Power Required	Rpm		Dimension in mm			Net Weight	Gross Weight	Shipping Measurement
			Rice	Wheat	Height	Width	Length			
No. 1	300-1,000 kg	3-5 h.p.	720	750	1,046	1,070	1,287	144 kg	260 kg	60 cu. ft.
No. 2	approx. 350 kg	½-2 h.p.	530	630	1,090	875	1,370	80 kg	115 kg	35 cu. ft.
No. 3	approx. 450 kg	½-2 h.p.	530	630	1,090	950	1,370	95 kg	130 kg	38 cu. ft.
No. 4	approx. 500 kg	1-2 h.p.	530	630	1,090	1,000	1,370	100 kg	140 kg	40 cu. ft.

CeCoCo Power Thresher No. 1 Double Drum, No. 2, 3, and 4 Single Drum

These units are for long- or short-cut stems of rice, wheat, sunflower seed, and sorghum. The crops are fed by hand into the threshing chamber and a perfectly cleaned grain exits from the outlet on the side of the conveyor-elevator after being completely threshed. The machine is equipped with winnower, conveyor, thrower, and speed adjuster which controls the air velocity.

CeCoCo Universal

CeCoCo Universal Power Thresher Type T25H is capable of threshing various kinds of beans, pulses, rice, sunflower seed, and wheat by replacing the screen and V-belt between the pulleys of the threshing drum and winnower. Separation is adjustable and no winnowing is necessary. Second separation of grain and stalks scattered at the second outlet is also possible; therefore, complete separation can be made without waste. The interchangeable screen can easily be replaced according to the size of grain in order to prevent breakage.



CeCoCo Universal Power Thresher
Rob Johnston

SPECIFICATIONS OF CECOCO UNIVERSAL GRAIN THRESHER

Type	Capacity per hour	Power Required	Rpm	Size of Screen	Dimension in mm	Size of Drum	Net Weight	Gross Weight	Shipping Measurement
T25H	rice 500 kg	2-3 h.p.	550-600	750 × 595mm	1,100 H	756mmW	115 kg	220 kg	80 cu. ft.
	wheat 500 kg		650-700		1,300 W	×			
	beans 1,500 kg	3-5 h.p.	250-550		1,500 L	364mmϕ			

CeCoCo Bean Thresher

The CeCoCo bean thresher is made for threshing various beans and seeds of full length or short stalks. The materials are fed into the threshing chamber and threshed by a threshing drum with multiteeth. Only the pure and complete beans or seeds are carried by the screw conveyor to the vertical screw elevator, and then outside through the outlet of the elevator. Screens are easily interchangeable.

SPECIFICATIONS OF CECOCO BEAN THRESHER

Type	Capacity per hour	Power Required	Rpm	Dimension in mm			Net Weight	Gross Weight	Shipping Measurement
				Height	Weight	Length			
M	30 ares in soybean	2-3 h.p.	600-650	1,010	860	1,010	110 kg	160 kg	50 cu. ft.

CeCoCo Peanut Thresher

This machine will thresh peanuts from peanut plants harvested with vines. Care should be taken to give proper speed of revolution to the machine. If it is too fast, it will damage not only the husks but also the kernels. If it is too slow, it will mix stalks, because imperfect separation will retard the threshing efficiency.

SPECIFICATIONS OF CECOCO PEANUT THRESHERS

Type	Capacity per hour	Power Required	Rpm	Dimension in mm			Net Weight	Gross Weight	Shipping Measurement
				Height	Width	Length			
No. 1	0.37 acre	2 h.p.	350	1,400	1,000	1,260	150 kg	280 kg	80 cu. ft.
No. 2	0.25 acre	1 h.p.	350	1,380	830	1,230	115 kg	200 kg	65 cu. ft.

The above threshers are manufactured by:
CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Porta-fast Grain Thresher

This is a mini-size portable thresher for easy transport for in-field operation. With a built-in winnower and 5 h.p. gasoline motor, it has a capacity of 12 to 20 CAV per hour and 15 to 25 CAV per hour with an 8 h.p. motor.

Jamandre Industries, Inc.
88 Rizal St.
Iloilo City 5901, Philippines

Small-Capacity Motor-Driven Thresher Model TDG-400

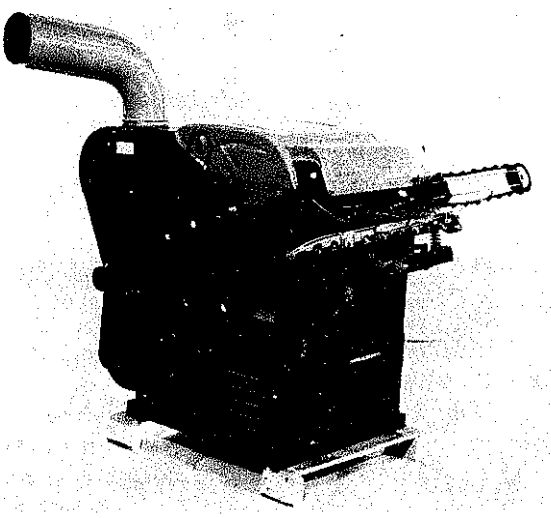
Designed mainly for threshing rice and wheat, this machine adapts well to wet threshing work. The machine consists primarily of a main drum, auxiliary drum, feed chain, sieves, grain conveyor, winnowing fan, and a 5.4 h.p. electric motor. It can thresh 600 to 1,000 kilograms of rice or 350 to 750 kilograms of wheat per hour. It weighs 164 kilograms and measures 130 by 1,392 by 1,150 millimeters.

China Agricultural Machinery Import and Export Corp.
Tientsin Branch 14, Chang Teh Road
Tientsin, China

Thresher Models D710S, D610S, and D510S

The differences in Iseki's three models stem from the three different cylinder widths: 500, 400, and 355 millimeters, respectively. Its power requirements range from 0.7 to 4.5 h.p. for an output capacity ranging from 10 to 30 ares (one are = $\frac{1}{20}$ acre) per hour.

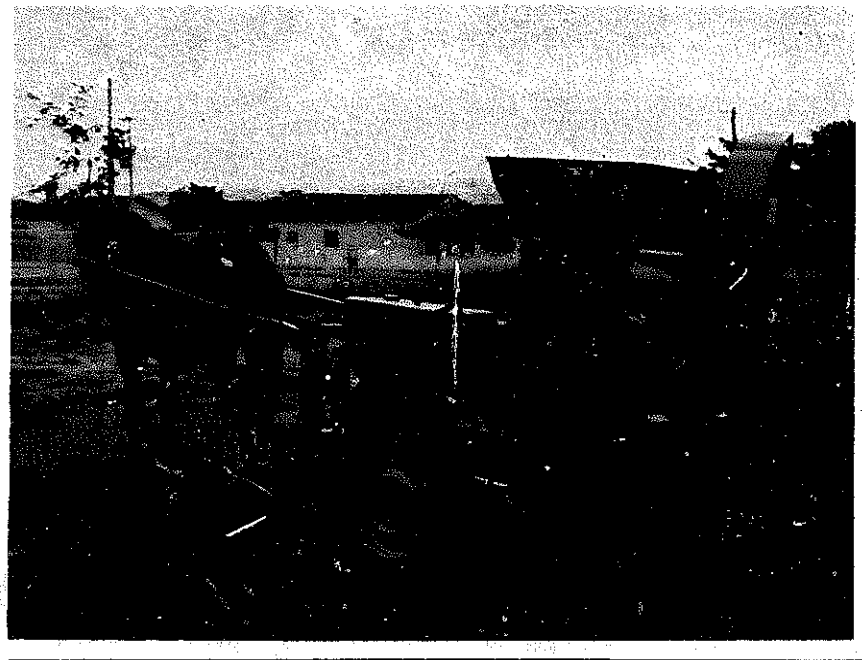
Iseki Agricultural Machinery Mfg. Co., Ltd.
2-1-3 Nihonbashi, Chuo-ku
Tokyo 13, Japan



Iseki Power Thresher
Agriculture Canada

Bel-500 Thresher

This unit was specially designed for stationary threshing and for cleaning corn and beans. It requires a 5 to 7 h.p. electric motor, or it can be run from a tractor's PTO. It will produce from 6,614 to 7,937 pounds per hour, tractor- or horse-drawn.



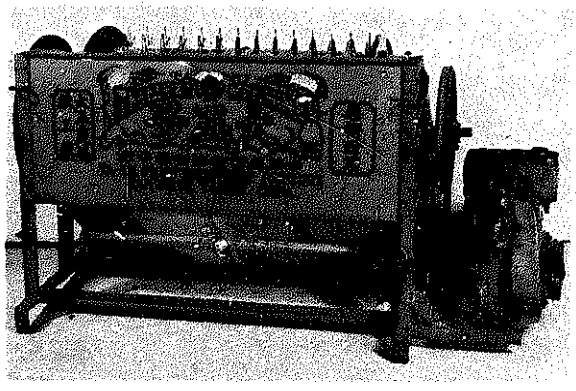
Laredo Cereal Thresher
Model Bel-500
Laredo

Laredo S.A.
Rua 1 de Agosto, 11-67-17.100
Bauru (SP) Brazil

TY-200

This unit threshes grains while separating leaves and roots from the grain with the powerful blower. It can be used with damp crops, weighs 120 kilograms, and measures 68 by 45 by 39 inches. It has an output of 1,000 kilograms per hour using a 5 to 6 h.p. motor.

Tien Chien Enterprises Co., Ltd.
P.O. Box 20-18 Taichung
Taiwan R.O.C.



Tien Chien Thresher
Tien Chien Enterprises

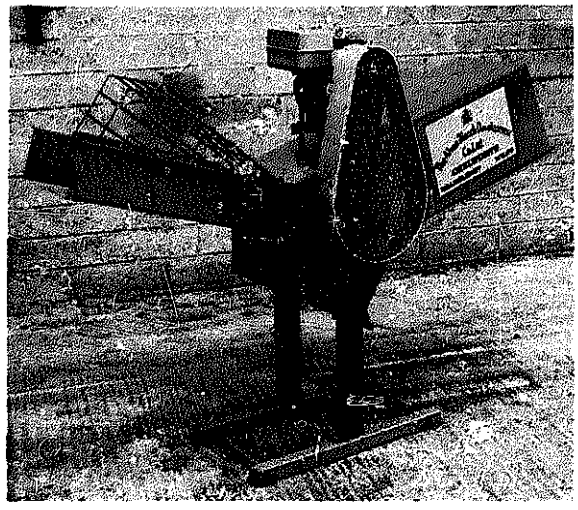
Agrima Rice Thresher Model TAP-20

This is a 3 h.p., gasoline engine thresher adapted from a treadle unit. It measures 55 by 120 by 68 centimeters and weighs 69 kilograms.

China Agricultural Machinery Co. Ltd.
17 Nanking Road, East, 1st Sec.
Taipei, Taiwan R.O.C.

Midget II Thresher

The Midget MKII is comprised of a basic



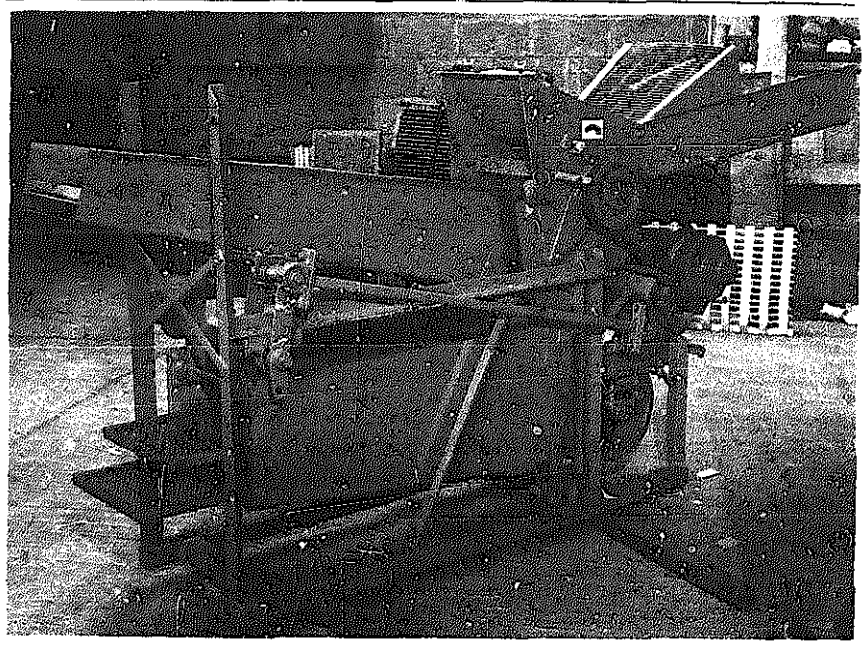
Alvan Blanch Midget II
Alvan Blanch Development Co.

rasp bar drum and concave, feed shute, and discharge cowl, and a collecting tray with a canvas shield. It requires 3 h.p. and can be driven by a gasoline or electric engine or tractor PTO. It weighs 280 pounds, measures 1 foot 11 inches by 4 feet 8 inches by 6 feet 3 inches and puts out up to 1,500 kilograms per hour of rice. Its other suggested uses include wheat, barley, oats, beans, peas, sorghum, maize, and millet.

Super Midget II

Requiring 5 h.p., this unit will put out up to one ton of rice per hour. Other larger units are also available.

Alvan Blanch Development Co., Ltd.
Chelworth, Malmesbury
Wiltshire, SN16 9SG, England



Alvan Blanch Super Midget II
Alvan Blanch Development Co.

Small-Size Automatic Thresher

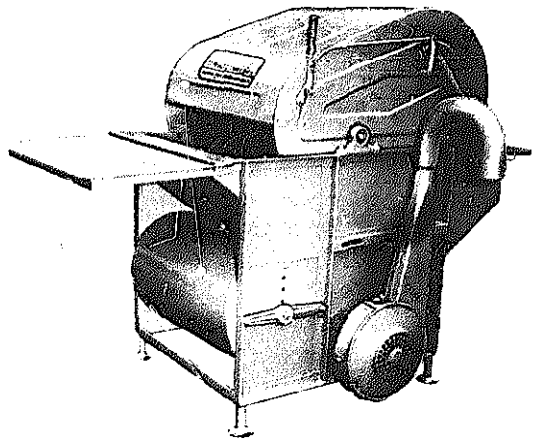
This Indian thresher can be run by a 10 h.p. electric motor, 12 to 14 h.p. gasoline motor, or the PTO of a 14 to 20 h.p. tractor. Larger units are also available.

New Bharat Industries (Regd.)
Industrial Area
MOGA (Punjab) India

Power Wheat Thresher-Cum-Winnower

Fifteen h.p. is required to run this thresher with a 1.06-meter-wide drum for a capacity of 400 to 500 kilograms per hour.

Rajasthan State Agro Industries Corp., Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006, Rajasthan, India



Akshat AK-58 Thresher
American Spring and Pressing Works

Akshat AK-58 Thresher

The Akshat AK-58 consists of a threshing

chamber, separator, dust-discharging device, and a grain-conveying and elevating mechanism. The threshing chamber contains a drum with fifty steel wire loops and a concave grill.

Stalks are held with both hands in a bunch, and the heads are inserted into the threshing chamber. The revolving drum combs out the grain, which falls through the grill into the winnowing chamber. Clean grain is raised by the elevator for bagging. The thresher requires 2 h.p. and can thresh 200 kilograms of rice per hour. Weight: 112 kilograms.

American Spring & Pressing Works Pvt., Ltd.
P.O. Box 7602 Malad
Bombay 400 064, India

Embee Power Thresher

This all-steel thresher is fitted with a threshing cylinder, grain auger, and elevator. The crop bundle is held in both hands and the heads are threshed between the loops of the rotating cylinder and the concave screen. The grain is separated from the chaff by a blower. The unit requires a 2 to 3 h.p. motor to put out 60 to 120 kilograms per hour of rice, or 100 to 150 kilograms per hour of wheat. Martin Burn also offers a conventional model thresher in which the complete crop is fed into the machine rather than just the heads.

Martin Burn, Ltd.
12 Mission Row
Calcutta 1, India

Wheat Thresher

The Wheat Thresher is designed primarily for wheat, although it will handle other crops. It is equipped with a winnowing fan and fills bags automatically. It has an output capacity of 200 kilograms per hour with a 5 h.p. motor.

Union Forgings
Sherpur, G.Y. Road
Ludhiana, Punjab, India

Model 42 Thresher

This simple thresher has no cleaning mechanism. It has an output of 1,300 to 1,600 kilograms per hour of straw and grain and requires approximately 2 h.p. to drive the machine. Larger models with cleaning mechanisms are also available.

Ets Cimon Freres
B.P. 47
50104 Cherbourg, France

ST-70 Thresher-Cum-Winnower

The ST-70 employs a rasp bar drum and concave to thresh rice, wheat, barley, beans, peas, maize, and other crops. It has an 18-inch drum which revolves at from 460 to 1,460 rpm for a wheat output of 1,500 to 2,000 kilograms per hour and a maize output of 3,000 to 4,000 kilograms per hour.

Vicon, Ltd.
Mudambai House, Lavelle Road
Bangalore-1, India

Jeco Threshers

Available in small and large sizes.

Jeco Engineering Co. (Regd.)
Near Shama Cinema, G.T. Road
P.O. Box No. 46
Gujranwala, Pakistan

Vogel-type Paddy Thresher

Similar to the Allan Vogel thresher described earlier, this unit is designed to yield grain of seed quality by avoiding damage to the grain. Damage to the kernel limits its germination capabilities. This machine has a 500-millimeter-wide drum, requires 10 h.p. to run, and produces 500 to 700 kilograms per hour.

Midget Rice Thresher

Similar to the Alvan Blanch Midget II thresher, this unit has a capacity of from 900 to 1,000 kilograms per hour. A 12 h.p. motor is required to run the 690-millimeter-wide drum.

A.P. Rodriguez Agro Industrial Machineries
Bitas
Cabantuan City, Philippines

THE AXIAL FLOW THRESHER

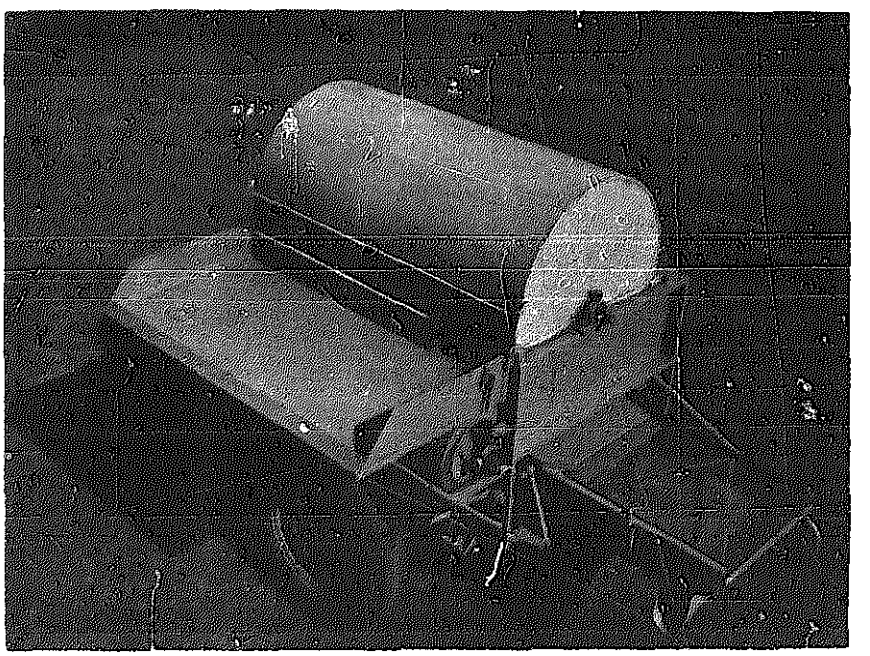
by The International Rice Research Institute

The widespread use of combines for harvesting and threshing crops in developed countries has led to a decline in the production and use of stationary threshers. Yet traditional methods are no longer suitable for threshing large quantities of rice, particularly in areas of multiple cropping. High-moisture paddy is difficult to thresh with conventional threshers available in the less-developed countries. The threshing output of the Japanese stripping-type thresher is generally low, and such machines are difficult to manufacture in less-developed countries. The International Rice Research Institute has developed the axial flow thresher for small- and medium-scale tropical farmers to use either through individual ownership or through contract threshing.

This machine can efficiently thresh rice, sorghum, soybeans, and other small grain crops over a wide range of grain moisture levels with low crop losses. The throw-in feed design and the axial movement of materials are distinguishing features of this machine. Separation and cleaning efficiency are excellent, and power requirements are low.

The thresher is mounted on two large wheels to provide good mobility on rough roads. It can be pulled easily with a power tiller or jeep, or it can be moved manually over shorter distances. A self-propelled version of the thresher has a motorized third wheel mounted on the front. The same seven horsepower engine provides power for threshing and transport. The self-propelled version is designed for custom threshing operations, which often require repeated movement of the thresher. When the ground is too soft to support the wheels, skids are available to attach to the underside of the thresher so that it can be pulled by animals.

The thresher can be powered by a seven to ten horsepower, air-cooled, gasoline engine. Power is transmitted through a series of V-belts to the five major components: the threshing cylinder, delivery auger, centrifugal blower, rotary screen, and aspirator fan. The threshing mechanism consists of a peg-tooth cylinder which rotates inside a full-circle cylindrical concave in two sections. The upper concave has spiral deflectors which move the threshing material axially between the threshing drum and the concaves.



IRRI Axial Flow Thresher
Union Tractor Workshop

This machine is well accepted and is gaining popularity among farmers across the Philippines. Twelve Philippine companies now produce the thresher. It is also being produced on a limited basis in Ghana, India, Indonesia, Pakistan, South Vietnam, Sri Lanka, and Thailand, and is being evaluated in Bangladesh, Guatemala, Peru, Korea, and Malaysia. The machine is being marketed for threshing soybeans and sorghum as well as paddy, and work is underway to adapt it for wheat threshing.

Engineering designs are available to manufacturers who are seriously interested in producing the thresher. Each request must be submitted on company letterheads with a history of the company and a list of available equipment, staff, capital structure, and product lines, along with tentative plans for production and marketing. Write to: The Agricultural Engineering Department, International Rice Research Institute, PO Box 933, Manila, Philippines.

An example of the IRRI-designed axial flow thresher is pictured here, manufactured by the Union Tractor Workshop in India.

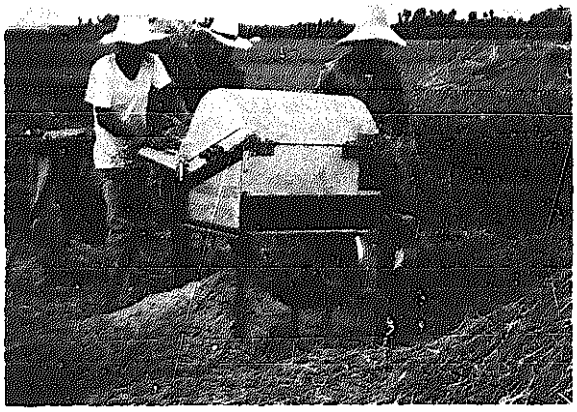
7.5 Axial Flow Thresher

This unit was developed for small- and medium-scale farmers to use either through individual ownership or through contract threshing. This machine can efficiently thresh rice, sorghum, soybeans, and other small grain crops over a wide range of grain moisture levels. Distinguishing features of this machine include throw-in feeding, axial movement of materials, low power requirement, and excellent separation and cleaning efficiency. Paddy output is about 1 ton per hour when operated with a three-man crew and a 7.5 h.p. motor.

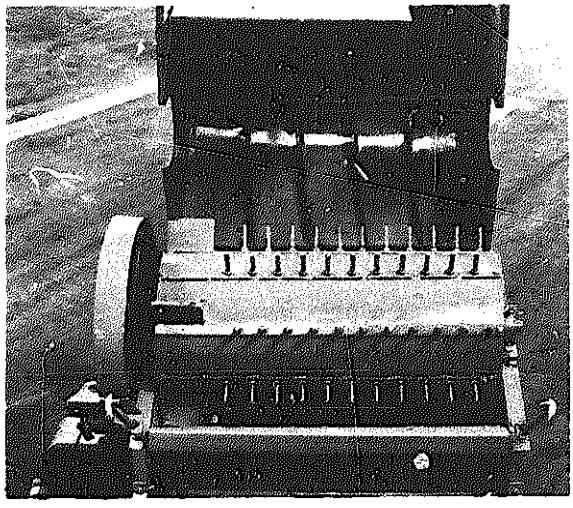
Union Tractor Workshop
8-B, Phase II, Maya Puri Industrial Area
New Delhi 110 027, India

Portable Axial Flow Thresher

The Portable Axial Flow unit has an output of 300 to 600 kilograms per hour of threshed paddy with a 5 h.p. engine. Two or three people are required to feed the machine, thresh, and bag the grain, and two men are required to move it. It has a multicrop capability for rice, sorghum, and other small grains. The unit weighs 105 kilograms with the engine, measures 96 by 76 by 138 centimeters, and uses about 1 liter of fuel per hour.



IRRI Axial Flow Thresher in operation in the field.
International Rice Research Institute



The spike-toothed threshing cylinder of the Axial Flow Thresher.
International Rice Research Institute

International Rice Research Institute
Box 933
Manila, Philippines

POWER DRUMMY THRESHERS

Drummy threshers usually incorporate 12

beaters inside a threshing drum to separate wheat from its hull. A winnowing fan attached under the machine separates straw from the grain but does not leave a cleaned grain; an average of 3.5 percent waste is left. There is no bagging arrangement with most of these machines, though adaptations can be made. The minimum power needed to thresh with a minimum amount of grain breakage is 470 revolutions per minute, as established by the Indian Council of Agricultural Research in New Delhi. At a lower speed, more breakage takes place.

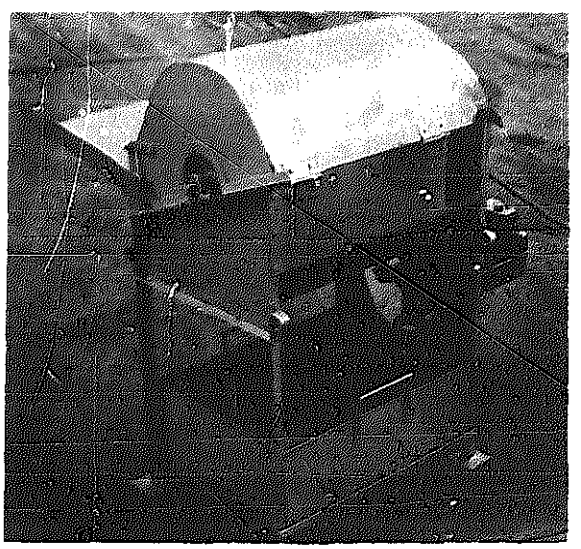
SOURCES OF DRUMMY THRESHERS

Union Tractor Drummy Thresher

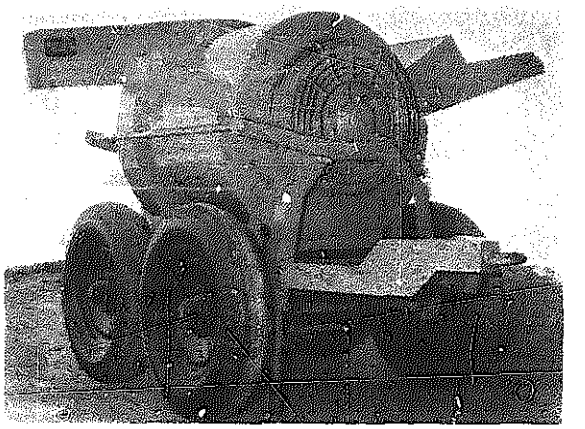
This is a very simple machine, particularly suitable for areas where farmers are being introduced for the first time to mechanical threshing. The threshing cylinder is the same as that on a complete thresher-winnower, but the threshed material falls directly onto the ground. A fan blows most of the chaff away from the grain, but some hand winnowing is still necessary.

Two sizes of threshers are available. The 75 centimeter size uses a 5 h.p. motor to produce 150 kilograms per hour and the 90 centimeter size uses a 10 h.p. motor for 250 kilograms per hour.

Union Tractor also has a full range of larger threshers and winnowers available, as well as the Pusa-40 Spike-Tooth Thresher, designed by the Indian Agricultural Research Institute, and the 4T-90 wheat thresher.



Union Tractor Drummy Thresher for the paddy.
Union Tractor Workshop



Union Tractor Wheat Thresher.
Union Tractor Workshop

Union Tractor Workshop is interested in establishing manufacturing facilities in other countries. Interested parties should contact Mr. Jagdish Chander.

Union Tractor Workshop
8-B Phase 11, Mayapuri Industrial Area
New Delhi 110 027, India

Power Threshers

U.P. State Agro Industrial Corp., Ltd.
Agricultural Workshop, Talkatora Road
Lucknow, U.P. India

Allied Drummy Thresher

Drum width on these units comes in five sizes ranging from 2¼ to 3½ feet, for an output of anywhere from 100 to 275 kilograms per hour. There are three 5 h.p. units, one 10, and one 15.

Allied Trading Co.
Railway Road
Ambala City 134 002
Haryana, India

Gepco Drummy Threshers

Gepco makes drummy threshers in three sizes. The 5 h.p. unit has a 76-centimeter drum and threshes at a rate of 180 kilograms per hour.

The 7½ h.p. unit has a 90-centimeter drum and a capacity of 300 kilograms per hour, and the 10 h.p. machine has a 105-centimeter drum and produces 450 kilograms per hour. Other units are also available.

Gepco Industries
Industrial Estate
Sonepat, Haryana, India

Drummy Thresher

Mohinder & Co. Allied Industries
Kurali, Distt. Ropar
Punjab, India

This machine is capable of threshing, winnowing, sieving, and bagging a variety of crops. Four people are required to operate this 3 h.p. unit to obtain a capacity of 300 to 500 kilograms per hour.

Jyoti, Ltd.
Baroda 390 003
India

Power Wheat Threshers

This Indian company manufactures threshers in a range of sizes, with or without winnowing mechanisms.

Khalsa Iron Works
2015 Railway Road
Narela, Delhi, India

Wheat Thresher

This small thresher is not fitted with a bagging mechanism and requires a power input of 5 to 7 h.p. Larger models and complete thresher-winnowers are also available.

New Bharat Industries
Industrial Area, Moga
Punjab, India

Saeco Power Wheat Threshers

The 90-centimeter (2½-foot) size has an output of 200 kilograms of clean grain per hour and requires 5 h.p. to run. Larger sizes are also available.

Standard Agricultural Engineering Co.
824/825 Industrial Area B
Ludhiana 141 003, Punjab, India

Hira Drummy Thresher

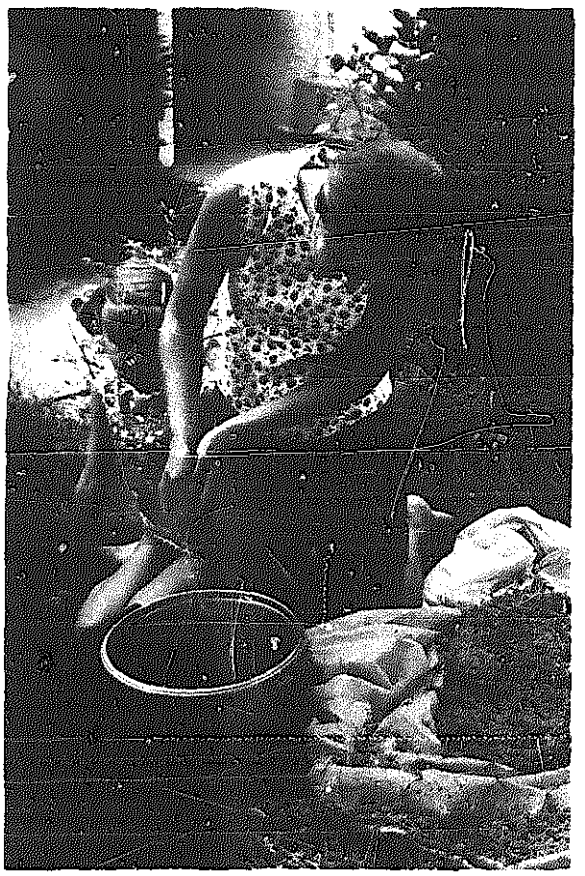
Four large drummy threshers are available from International Manufacturing. The drum sizes range in width from 24 to 42 inches. Power requirements vary from 3 to 10 h.p. for outputs of from 1,500 to 4,000 kilograms per hour. Complete combination thresher-winnowers are also available.

International Mfg. Co.
Hospital Road, Jagraon
Ludhiana, Punjab, India

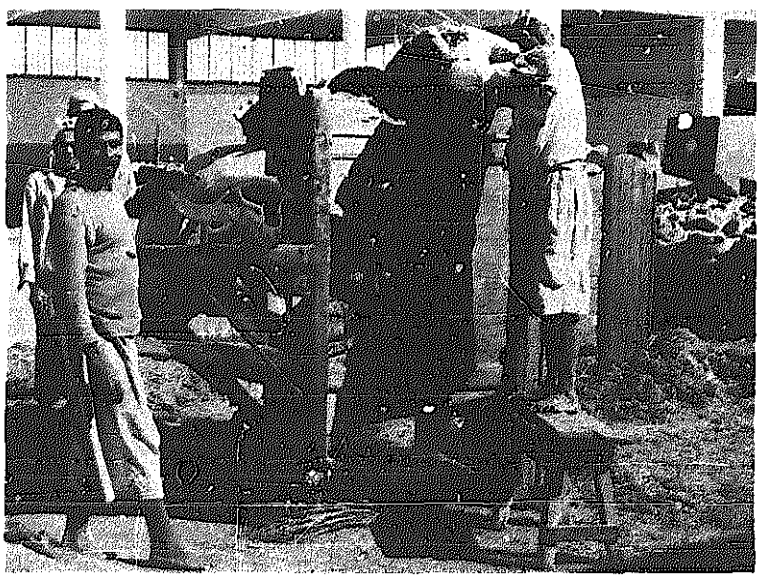
WINNOWERS

The practice of winnowing consists of using air moving in a horizontal direction to separate grain from chaff or dust by allowing the mixture to fall vertically in a thin stream across the path of the airflow. The lighter chaff is carried further by the moving air while the heavier grain falls nearer to vertical, with the material in between these grades occupying intermediate points according to their weight. This principle has been implemented by farmers for centuries in its simplest form, where the natural breezes in the open-air threshing yard are used. A fan can also be used, since it gives a steadier and more reliable air flow.

In a well-designed winnowing machine, the blast of air is produced by a fan rotating inside a suitable casing, while the material to be cleaned and graded falls vertically from a hopper held immediately above the fan outlet spout. In a combined winnowing and grading machine, after passing through the airstream the partially cleaned grain passes through a perforated shaker screen which retains the larger waste but allows the product to fall onto a second perforated shaker screen where small waste and dirt fall out. Finally, the product passes to the discharge chute. To achieve the maximum extraction of waste, the velocity of the airflow in the separation chamber can be adjusted over a wide range. The perforated shaker screens are usually se-



With the help of a fan or a good strong breeze, chaff is blown away as the heavier grain falls straight into the bucket.



This hand-operated thresher was manufactured in this Egyptian village with locally available materials and craftsmen.
Dr. B. N. Ghosh

cured by spring clips which are manually released so that the screens can be easily removed for changing or cleaning. A range of screen sizes are available to deal effectively with almost all kinds of seed. The cleaned grain can also be delivered to bagging spouts by using a bucket elevator.

The quality of work done by a winnower is

limited, and it also suffers from the disadvantage of the dust nuisance, not only in the simplest machines but also in the more complex units. The remedy lies in making proper arrangements at the time of installation for the collection and disposal of dust in an effective manner. The usual method is to blow the dust and chaff into a large settling box provided with a wire-covered outlet.

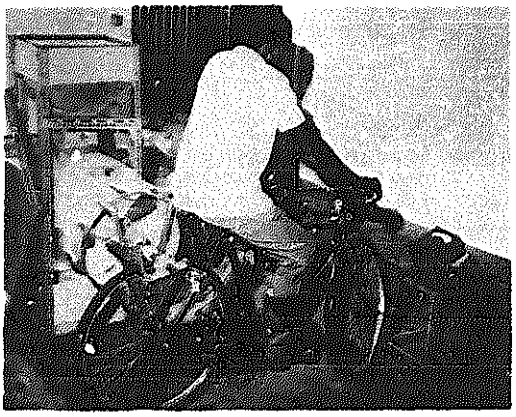
Since much of the threshing in developing countries is carried out by hand or by using simple machinery as described previously, winnowing frequently has to be conducted as a separate operation and is often done by hand. The output of hand winnowing is approximately 45 kilograms of grain per hour. A hand-driven mechanical winnower can achieve outputs of between 200 and 1,200 kilograms of grain per hour and produce a very clean sample suitable for seed.

The simplest winnowers consist of hand- or pedal-driven fans without any sieves or separation devices. The other winnowers described in this section can be adjusted for different crops and can also be fitted with a range of metal sieves. For example, a special hand-powered rotating screen device is available for separating groundnuts from husk and dirt.

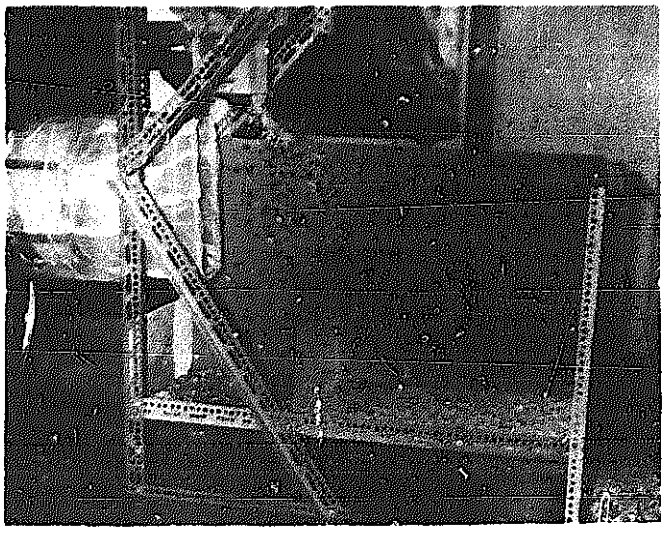
In developed countries, the winnowing process is usually incorporated into the function of the thresher. Hence, sources of winnowers alone are scarce in North America.

Prototype Pedal-Power Winnower

Most commercially available winnowing machines employ an electric motor or an internal combustion engine to drive the fan. These machines are too expensive for the small-scale farmer, and their capacities usually exceed his requirements. To meet the needs of the peasant



Dr. Ghosh's prototype pedal-powered winnower.
Dr. B. N. Ghosh

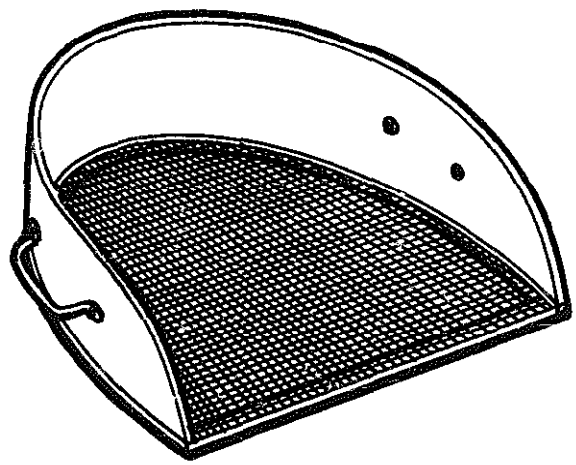


A demonstration of the pedal winnower in action. Notice that the larger, heavier matter falls first and that the lighter chaff is blown far away as the grain mixture falls from a hopper above.
Dr. B. N. Ghosh

farmer in India, an inexpensive winnowing machine which can be easily attached to and operated by a pedal bicycle (a vehicle which some peasant farmers already possess) is being developed by Dr. Biswa Ghosh.

An Old-Fashioned Winnower

This simple type of winnower predates hand-operated grain cleaners by a few hundred years. About the only improvement that has been made over traditional basket models is the addition of a screen to allow the fines, dust and dirt, to fall through. In use, the threshed grain is tossed into the air on a windy day—the wind blows away the chaff, dust, and the lighter seeds, the sand and smaller particles fall through the screen—and with any luck, what is left is cleaned grain. The sides are made of galvanized sheet metal, 8 inches high. The screen is galvanized and is riveted to the sides. Its size is 24 inches wide, and 24 inches deep (from front to back).



The AVI Winnower

American Village Institute
440 Meyers St.
Kettle Falls, WA 99141

Agrima Winnowers

Two models are available from this company, one made of metal and the other of wooden construction. Both can be operated by hand or with a small motor.

China Agricultural Machinery Co., Ltd.
17 Nanking Road, East, 1st Sec.
Taipei, Taiwan

Winnower

This firm offers a hand-driven winnower made of wood.

Self-Sufficiency & Small-Holding Supplies
The Old Palace, Priory Road, Wells
Somerset BA5 1SY England

CeCoCo Hand Grain Winnower Type A-I

This model is designed for cleaning paddy, hulled rice, wheat, barley, hulled sunflower seed, and any other grains or seeds.

With an output capacity of approximately 650 kilograms of hulled rice per hour, this unit separates cleaned grain from immature dead grain and chaff, husk, and dust. It is of all-steel construction. Weight: 300 kilograms.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567 Japan

Hindson Seed Grader

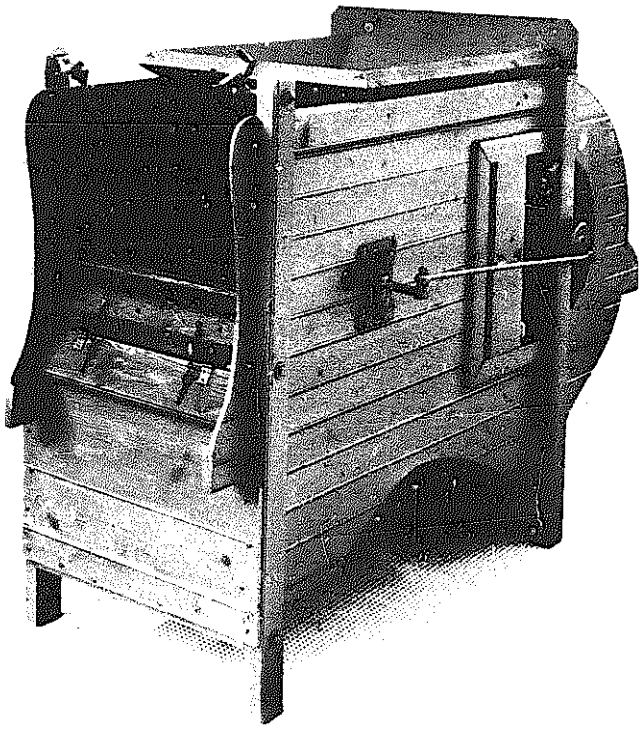
This model comes equipped with an adjustable blower and two replaceable sieves. It has a capacity of 600 to 1,100 kilograms per hour with a ½ h.p. motor. Four sieve sizes are available.

Hindsons Pvt. Ltd.
The Lower Mall
Patiala, Punjab, India

Number 8 Winnower

This is a hand-powered machine constructed mainly of wood, but with metal moving parts and an oscillating bottom screen. It can be fitted with any of five 40- by 40-centimeter metal sieves for efficient screening of all kinds of grain, including wheat, barley, and maize.

R. Hunt & Co., Ltd., Atlas Works
Earls Colne, Colchester
Essex CO6 2EP U.K.



Hunt No. 8 Winnower
R. Hunt

An Indian Winnower

The air draft on this model is controllable, and you can replace the sieves as necessary. It runs on four ball bearings and is operated by hand.

Rajasthan State Agro Industrial Corp., Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006, Rajasthan, India

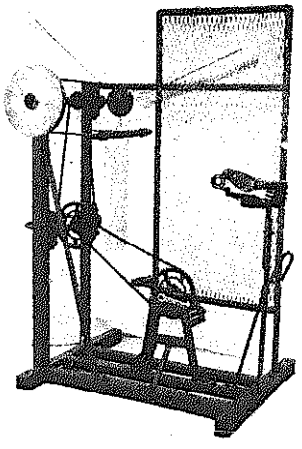
A British Winnower

This unit consists of a hopper, feed control slide, oscillating sieve assembly, and fan. It is available in two models with approximate capacities of 800 kilograms per hour and 1,000 kilograms per hour. Both models can be hand- or power-operated.

The Alvan Blanch Development Co., Ltd.
Chelworth, Malmesbury
Wiltshire SN16 9SG U.K.

Cycle Winnower

With a capacity of 1,500 to 2,000 kilograms per hour, this simple pedal-driven fan aids the farmer when natural breezes fail to blow. The blades have a span of 1,200 millimeters (48 inches) and are fitted onto a shaft running on two ball bearings. There are two freewheels in the gear train along with a flywheel. A seat is provided on this all-steel, 80,000-kilogram, framed unit. Enough air current is provided to keep four people winnowing at one time.

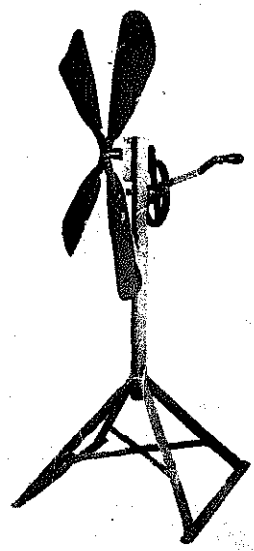


Cossul Cycle Winnower
Cossul and Co.

Cossul Hand Winnower

This hand-driven model has a capacity of 500 to 800 kilograms per hour, and will keep two people busy winnowing at a time. The blades are fitted to a post, and the unit weighs 25,000 kilograms.

Cossul Co. Pvt. Ltd.
Industrial Area
Fazalgunj, Kanpur, India



Cossul Hand Winnower
Cossul and Co.

The Winnower Kit

A winnower has been developed by the Overseas Liaison Department of the National Institute of Agricultural Engineering in England to meet the need for a hand-driven device for separating grain from chaff and groundnut kernels from their shells. The design is simple, and manufacture should be well within the capability of village craftsmen using normal hand tools.

The winnower consists of a frame supporting a feed hopper, separating duct, fan, and drive mechanism. The frame is made of ten wooden pieces bolted together. The hopper is formed by the two upper frame members, the top of the fan casing, and one side of the separating duct, which has a shuttered feed aperture level with the hopper floor.

The duct is of rectangular cross-section, roughly S-shaped, with a long vertical center part. The shaped sides are cut from thick plywood and the sheet metal front and back are screwed to the edges of the plywood. The fan is a plain paddle blade unit. The casing is constructed in the same way as the duct to which it is attached by a bolted, flanged joint. A six-blade wooden rotor is carried on a steel shaft running in plain wooden bearings bolted to the frame.

The drive is transmitted by bicycle chain from a crank and chain wheel to a small sprocket on the fan shaft. All the components are standard bicycle parts. The pedal crank and chain wheel are soldered to a steel shaft which runs in bearings bolted below the hopper. The small sprocket on the fan shaft is made from the ring of teeth from a bicycle freewheel pressed onto a wooden boss which is pinned to the shaft.

The following table summarizes the performance results of a prototype at an N.I.A.E. trial. Measurements of output were taken during short runs without stops for refilling the hopper. The rate of work over several hours may be lower, depending on the number of operators and their efficiency.

Crop	Crank Speed, Revolutions per Minute	Average Output Kilograms per Hour	% of Chaff or Shell Removed
Rice (long grain)	70-90	400	75-95
Groundnuts (North African)	84-94	250	83-99
Groundnuts (Gambian)	90	180	98

When the trial was conducted, researchers found that some of the rice samples contained short straw which could not be blown out. In the North Africa groundnut trial, the winnower's high crank speed gave a very clean result, but the Gambian groundnut trial yielded a poor sample, with 40 percent of the nuts left unshelled.

Overseas Department
National Institute of Agricultural Engineering
Silsoe, Bedford MK45 4HS England

A Dutch Winnower Kit

This kit offers the option of assembling the winnower after completing construction of the individual parts or assembling from a pre-assembled kit. This winnower is made of wood with metal working parts. Only the simplest shop tools are necessary for its construction.

Tool
Postbox 525
Eindhoven, Netherlands

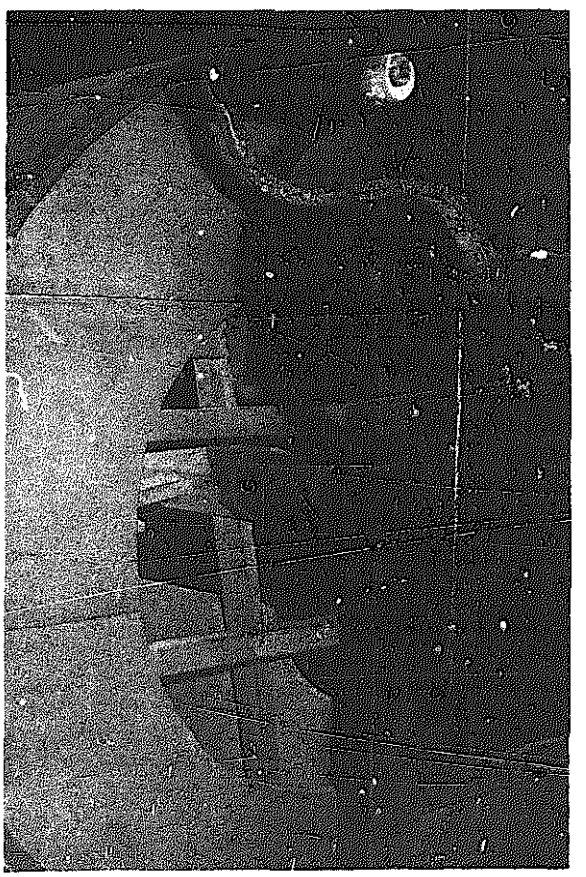
CLEANING AND GRADING

Specially designed cleaning and grading machines can improve the quality of a sample grain to a considerable extent beyond the capabilities of the winnower. There are several reasons why such high-quality grain is desirable:

1) Grain required for seed purposes should be clean and uniform;
2) Removing weed seeds means that cultivation of the growing crop will be less costly;
3) An increased yield can be obtained from using cleaned and graded grains for seed purposes;
4) Seed-drilling machines perform better when clean and properly graded seed is used;
5) You can get better prices for graded samples;
6) Removal of insects and other foreign matter during cleaning ensures better and safer storage;



A hand-operated seed cleaner constructed entirely of wood. The crank powers a wooden-bladed fan for winnowing while screens in the foreground separate seed from chaff. Cleaned seed is deposited in a drawer below. No longer being made in the United States, these machines are easy to find at farm auctions but are now gaining in value as antiques. Construction plans are available from IRRI, Box 933, Manila, Philippines.



The hand crank, gears, and a peek at the wooden fan blades of an old seed cleaner.

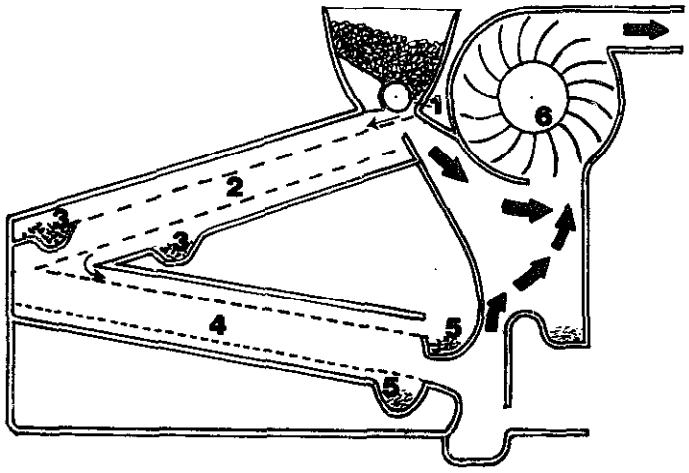
7) Grain that is precleaned before drying improves the efficiency of the drying machine and produces a more uniformly dried sample.

In cleaning grain or seed, the main object is to separate all chaff, straw, weed seeds, broken and inferior seeds, dust, and other assorted rubbish from the sample. (However, some of this material can be a useful by-product with commercial value.)

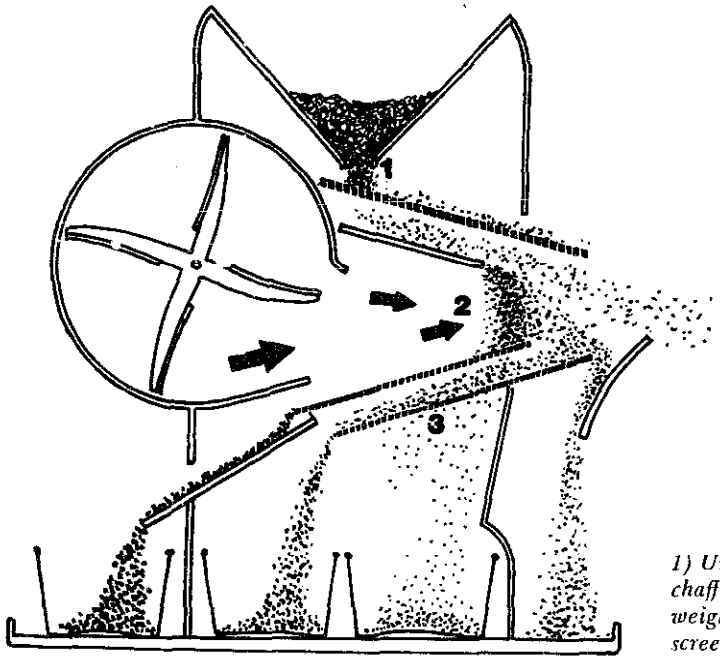
Most machines used for cleaning also grade the grain according to size, shape, specific gravity, and/or weight of the seed. Seed cleaners commonly used on farms vary considerably in the quality of work done. The cleaner may be a very simple riddling or winnowing machine, or a complex dresser which employs a number of processes to treat or dress the grain. Some of the processes commonly used by seed cleaners are:

1) Screening over a sieve in order to remove stalks, stones, and other large roughage.
2) Separation by a blast of air, using either a winnowing or an aspirating device.

Two Methods of Cleaning and Grading Seed.



1) Uncleaned mixture leaves hopper and 2) passes across large mesh screen. 3) Large matter collects in pockets at end. 4) Mixture passes over finer meshed screens into 5) more collection pockets. 6) Fan keeps dust and fine particles moving to exit.



1) Uncleaned mixture leaves hopper. 2) Fan blows chaff through exit hole and separates seed by weight. 3) Seed passes across different meshed screening for four grades.

3) Rotary screens or nests of sieves usually separate the grain or seed into a number of samples according to width.
4) Indented cylinders or pockets are used to separate the sample according to length.

Some machines will simultaneously clean and grade a sample of grain or seed, while others will perform only one of these functions. They are grouped below according to the mechanism used for cleaning and/or grading.

OPERATING AND ADJUSTING CLEANERS AND GRADERS

Considerable skill is required to operate efficiently the various types of cleaners and graders that are available for farm use. Grain samples are variable and the correct setting for one particular sample may not be appropriate for the next sample. The following adjustments are usually available to properly set a machine for a given sample of grain:

1) The air blast can be adjusted by either regulating the fan blind or altering the speed of rotation.
2) The slope, length, and frequency of vibration of a machine can be adjusted to suit the requirements of a particular sample.
3) The sieves themselves are interchangeable for different sizes and types of grains.

NORTH AMERICAN SOURCES OF SEED CLEANERS

The Model 30 Burrows Seed Cleaner and Grader

This is a small-sized seed cleaner and grader, suitable for seed testing or cleaning small lots of seed. It has a small chaff or scalping screen on top and large cleaning and grading screens below. Standard equipment includes any four chaff–grading screens and any four double-grading screens. A suction fan removes chaff, and the screens remove large particles and damaged seeds. Its capacity for wheat and other grains is 20 to 30 bushels per hour. For clover and other seeds, it can process 2 to 10 bushels per hour. Shipping weight of this cleaner is 145 pounds. The screens weigh extra. This unit can be operated by hand or a ¼ h.p. motor. A bagging attachment is available.

Model 75 Burrows Seed and Grain Cleaner and Grader

This unit has a capacity of 60 to 75 bushels per hour when cleaning and grading wheat or other heavy grains, and 10 to 25 bushels per hour when cleaning and grading clover and other lighter seeds. This is a four-screen machine which has two separate shoes with two screens in each shoe. The scalping screens remove sticks, stems, pods, and other large particles; the grading screens clean the seed or grain and separate the cleaned seed into two grades when two screens are used. A high-speed multivane fan removes chaff and other light material. The Model 75 Burrows requires a ½ h.p. electric motor for use without an elevator. When a charging elevator is used with the cleaner, a ¾ h.p. electric motor is needed.

Burrows Heavy-Duty Double-Spiral Separator

This machine separates anything round from anything that is not round, according to the manufacturer. Vetch, peas, soybeans, pepper, rape, turnip, coriander, milo, mustard, and other round seeds are easily separated from wheat, oats, barley, flax, corn, screenings, rodent chips, etc. No power is needed. The Double Spiral separates by gravity to remove round seeds from oblong grains, screenings, or weeds.

The machine consists of two units of spirals which feed from the same hopper and deliver together at the bottom. At the top is a large hopper with an adjustable feed plate for each unit of spirals. The seed leaving the hopper runs over a cone divider which spreads the seed evenly to each of the five flights in each unit. Going down the flights, the round kernels travel at a much faster rate of speed than the other kernels. Their momentum increases until they run over the edges of the spirals, drop to the housing spiral and roll into a tray at the bottom of the machine. A single discharge chute is standard unless the double chute is specified. The double chute separates the round seed into two grades, portions of which can be controlled by adjusting levers.

The unit is built from galvanized steel, is set in a strong steel frame, and measures 77 inches high, 42 inches wide, and 22 inches deep. Its capacity is 10 to 50 bushels per hour (30 to

35 bushels per hour for soybeans). Shipping weight: 200 pounds. Available options include self-cleaning hopper, laboratory sample spiral (single, 5 feet by 20 inches, with two flights), heavy-duty single spiral (20 inches diameter).

Spiral Grain Cleaner Model 2825

As the screen and spiral rotate in this model, the spiral moves the grain over the screen. Because of the movement of the screen and spiral and the horizontal construction of the machine, the grain flow is completely controlled and distributed more effectively than in an operation depending on gravity. The spiral in the grain cleaner assures that the grain will be carried over the largest possible screen area. The result is thoroughly cleaned grain that dries faster to help eliminate spoilage. This cleaner is belt-driven for economical and reliable power. Easily interchangeable screens are available for most grains. The cleaner was designed for easy maintenance, and performance-tested to insure best results. Model 2825 is 24 inches in diameter and 6 feet long, with a capacity of 1,200 to 1,500 bushels per hour (for dry corn). It requires a 1 h.p. motor.

All the above cleaners are available from:
Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204

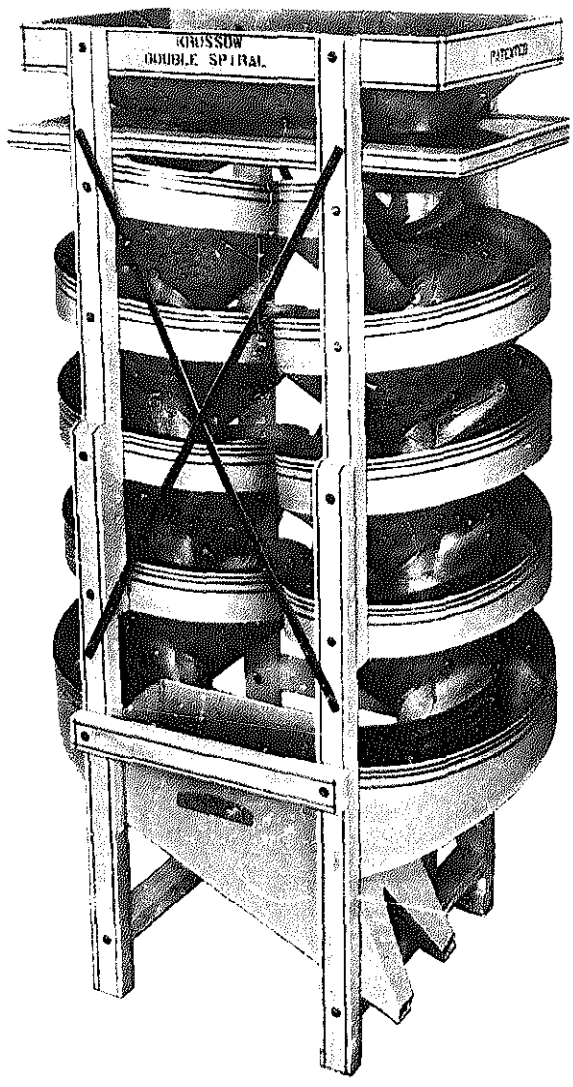
Seedburo Cleaner

The Seedburow No. 464 seed cleaner is similar to the Burrows No. 30.

Seedburo Equipment Co.
1022 W. Jackson Blvd.
Chicago, IL 60606

Power-driven Seed and Grain Cleaner

This unit cleans and grades 2 to 10 bushels of small seed and 20 to 30 bushels of large grains per hour. It has a galvanized steel housing, smooth-action upper scalping or chaff screen, controlled-vibration lower cleaning and grading screens, and the suction of an adjustable airstream. Eight screens provide 12 different screening combinations. The cleaner requires little operating or storage space; it measures 23 by 38 by 40 inches high. It is shipped from the factory near Columbus, Ohio.

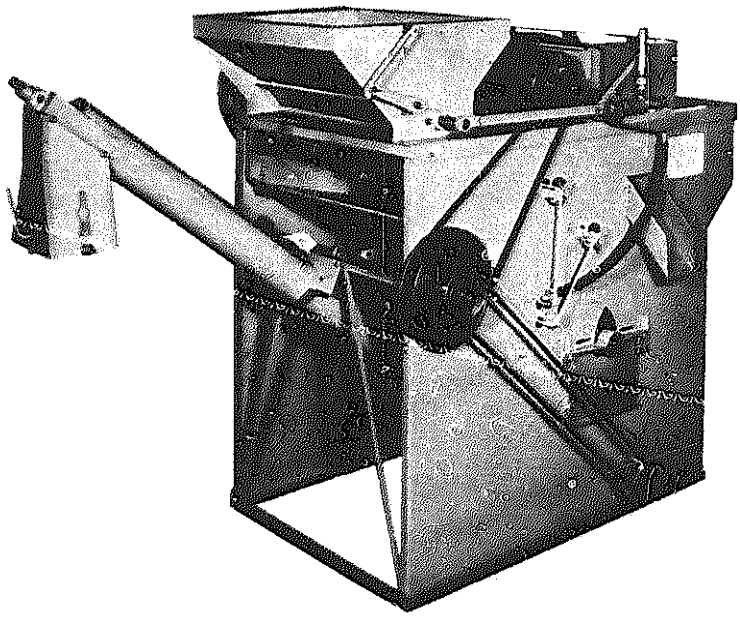


Spiral Separator
Seedburo Equipment Co.

Sears, Roebuck & Co.
Farm and Ranch Catalog

The Clipper for Sample Testing

The shoe of this model uses two 10- by 15-inch screens, one for top and the other for lower separation. The clipper also features a powerful blast fan driven by three step pulleys and controlled, adjustable shutters on air intake openings to provide intermediate air regulation. In



Clipper Seed and Grain Cleaner M-2B
Seedburo Equipment Co.

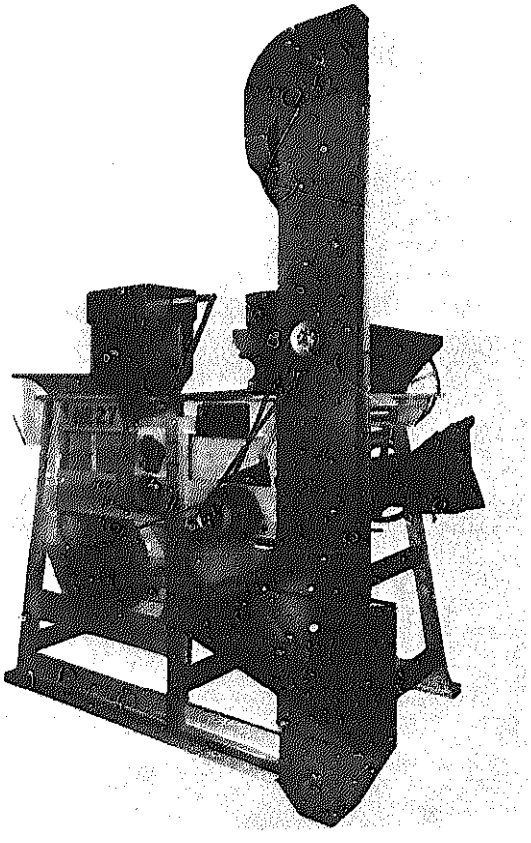
addition, it has a grain box and an air screening receptacle wth removable trays. This cleaner is operated either by a hand crank or by a ⅙ h.p. motor. The hand crank is furnished only if the motor is not mentioned on the order. Ten screens of the customer's choice and the cleaner drive pulley come as standard equipment. The Clipper Office Tester is 30 inches long, 15 inches wide, 23 inches high and weighs 45 pounds. Shipping weight: 90 pounds.

Clipper Hand-Testing Screens

Clipper Hand-Testing screens provide a liberal assortment of screens, enabling you to experiment with various separations and select the correct screens for each cleaning problem. For household use, you can use these hand screens to clean just as much as you intend to use. A storage rack is available.

Clipper M-2B

In this model, grain is fed to the hopper which spreads it evenly across the full width of the top screen. The top screen perforation is selected with large openings to hold up and scalp off large foreign matter while the grain drops through to the second screen. The lower screen is selected with openings slightly smaller than the grain. Dirt, splits, weed seeds, and im-



Clipper Seed and Grain Cleaner No. 27.
Seedburo Equipment Co.

mature kernels drop through this lower screen, and the clean grain discharges in the form of a curtain through the Bottom Air Blast Column. The bottom air is adjusted to remove any remaining lightweight trash or underweight kernels. This air separation is selective because the fan is precisely adjustable over a wide range. With a screen size of 24¼ inches by 22¼ inches and all-screen construction, this unit will clean up to 40 bushels per hour.

Crippin A-234, A-334 Seed Cleaners

The general construction and operation of the two-screen and three-screen models are similar. The first scalper on the three-screen model removes the largest trash and relieves the second scalper screen of this trash to provide more capacity and closer screening. In grading work, one more size can be obtained with this screen. All screens are interchangeable. With a 1 h.p. requirement, the Crippin Cleaner handles from 25 to 150 bushels of seeds per hour depending upon the stage of the seed.

These cleaners are available from:
Ferrell-Ross
1621 Wheeler St.
Saginaw, MI 48602

Nursery or Test Plot Threshers

These plot threshers, 14 inches standard or 18 inches heavy-duty, come assembled and ready for threshing small lots of grain such as sorghum, wheat, oats, soybeans, barley, and peas. Cylinder speeds are adjustable; the intake hoppers have baffles to prevent the grain from flying back out, and the air flow is adjustable for the type of grain being threshed. Both threshers have a secondary cleaning system that improves efficiency.

Maintenance is no problem: all pulleys, belts, and bearings are standard shelf items, and engine parts are easily available. Optional equipment includes a bagging spout and an extension hopper. Dimensions are 30 by 30 by 27 inches. The units weigh 200 pounds and require a 3 h.p. gasoline engine or a ¾ h.p. electric motor.

ALMACO, Allan Machine Co.
P.O. Box 112
Ames, IA 50010

Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204

KEM Corp.
Box 471
Haven, KS 67543

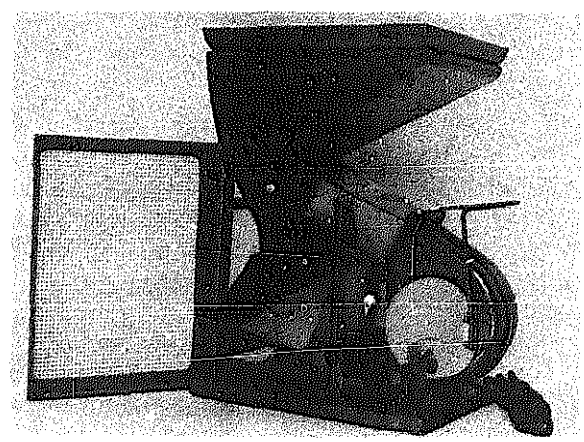
Nasco Agricultural Sciences
901 Janesville Ave.
Fort Atkinson, WI 53538

Seedburo Equipment Co.
1022 W. Jackson Blvd.
Chicago, IL 60606

Lee Grain Cleaner

Lee's Model A Cleaner uses a waterless cleaning process, tumbling each grain kernel between a rotating stone wheel and a stationary wheel. Each kernel is polished, scrubbed, and the outer hull scoured away by the rubbing action of the stones, without disturbing the germ. Following the dry scrubbing phase, the grain passes through an air separator which removes fine particles of dirt, dust, chaff, and bee's wings, or loose hulls. With the cleaner properly adjusted, dirt and foreign matter amount to about 2 percent of the final product by weight. The cleaner uses a dual voltage ¾ h.p. single-phase motor to clean 150 to 200 pounds of grain per hour.

Lee Engineering Co.
2023 W. Wisconsin Ave.
Milwaukee, WI 53201



ALMACO Air Blast Seed Cleaner Allan Machine Co.

Air Blast Seed Cleaner

Designed for the precision work of research experiments, the Air Blast Seed Cleaner has two interchangeable screens with 1/8-, 1/4-, 3/8-, and 1/2-inch wire mesh openings, two seed catch pans, and a 180-cubic-feet-per-minute blower. It is made of wood; dimensions are 20 by 12 by 23 inches.

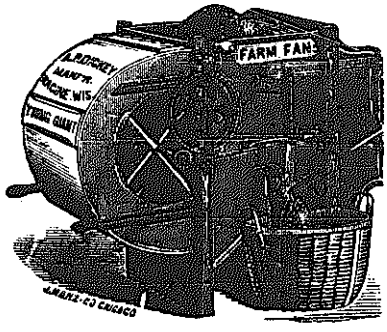
ALMACO, Allan Machine Co.
P.O. Box 112
Ames, IA 50010

Grain Cleaner

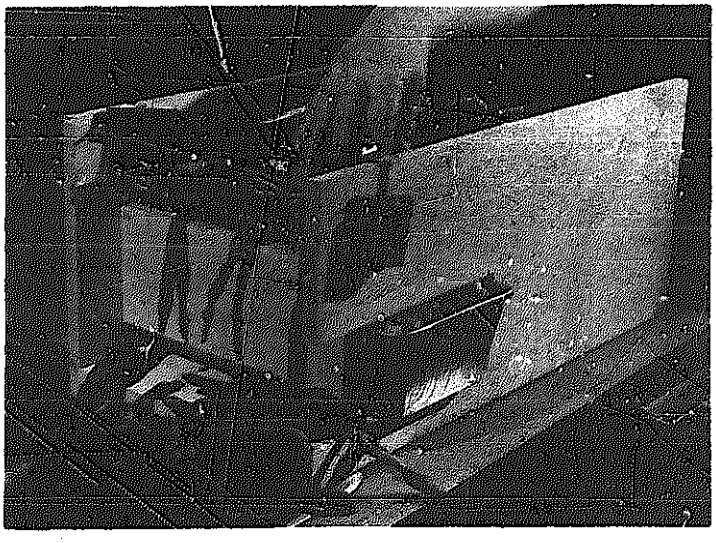
The AVI Grain Cleaner is patterned after the simple, efficient fanning mill cleaner-separator that was common around the turn of the century. This mill is designed for hand operation but may also be driven by any external power source. In operation, the threshed wheat is poured into the top hopper and is shaken through a series of screens which separate the grain from the dirt and chaff. The reciprocating action is accomplished by a cam and pitman arm attached to the camshaft. The fan itself is driven by a hand-operated sprocket and chain and essentially blows away all the chaff, dust, and lighter seeds. The cleaned and separated grain is ejected from a trough at the rear of the machine. All hardware is made of cast iron and steel. All screens are galvanized. The frame is of oak, and hopper and screen housings are of alder or maple. The fan is galvanized sheet metal, and is driven by a 6:1 ratio sprocket and chain assembly. The width of this cleaner is 28 inches, length is 42 inches, and height is 36 inches. Weight: approximately 125 pounds.

American Village Institute
440 Meyers St.
Kettle Falls, WA 99141

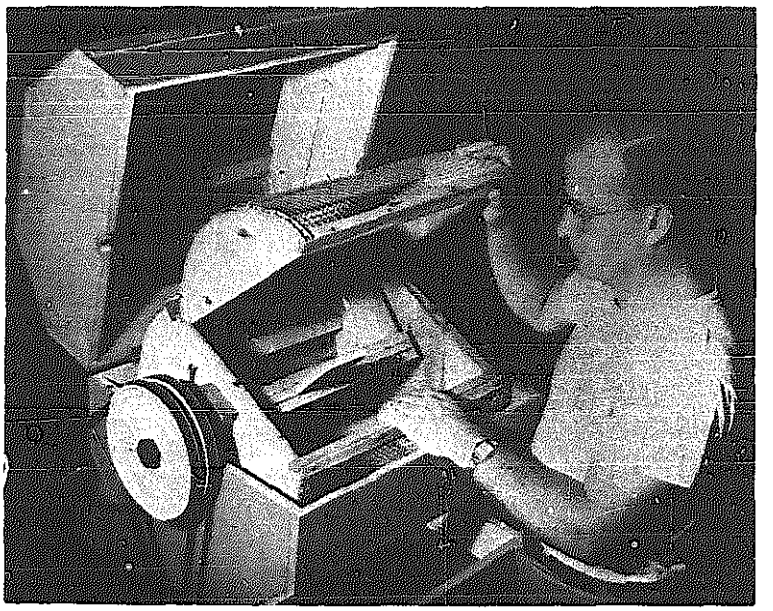
DICKEY
Fanning Mills.
Farm and Warehouse.
Of All Capacities.
Also TANK LUGS.
Band Fasteners for Tanks.
A. P. DICKEY MFG. CO., - Racine, Wis.



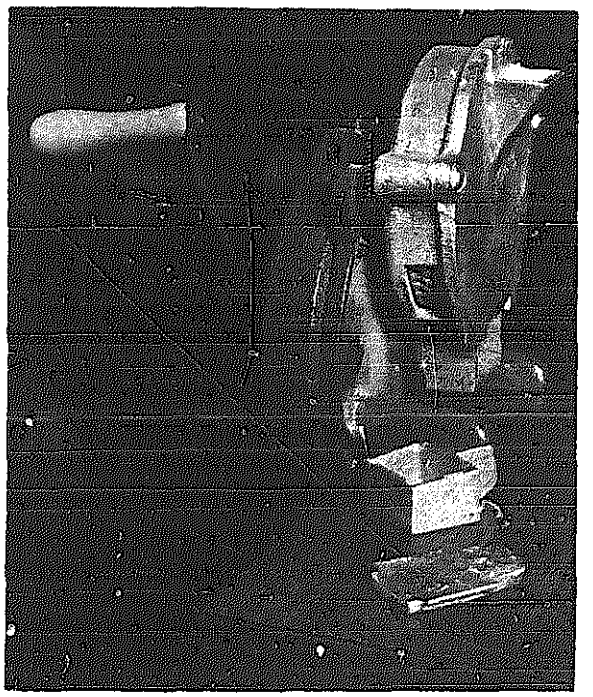
The Implement Age, 1894



The Mr. Pea Sheller shells all kinds of peas and beans—blackeye, purple hull, small crowder, cream peas, English peas, sweet peas, and the harder-to-shell limas and butter beans. Available from:
Mr. Pea Sheller
P.O. Box 29153-B
Dallas, TX 75229
R.E. Tenney & Associates



Plans for this pea and bean sheller are available from the Department of Agricultural Engineering, Cornell University, Ithaca, NY 14853. Ask for Agricultural Engineering Extension Bulletin No. 412.



Barley pearlers are becoming more generally available through homesteading catalogs. This one is manufactured by Seedburo Equipment Co.

INTERNATIONAL SOURCES OF GRAIN AND SEED CLEANERS

The N.I.A.E. Cleaner

The N.I.A.E. cleaner was developed for cleaning grain samples received from plot combines and threshers. As these samples often contain 60 to 70 percent chaff and straw, an air aspirator is used to remove this material first. The semicleaned sample then passes over a double sieve-cleaning riddle. Capacity is 25 samples per hour, based on samples received from the N.I.A.E. plot combine.

R.G. Garvie & Sons
2 Canal Road
Aberdeen, Scotland

CeCoCo Paddy Separator

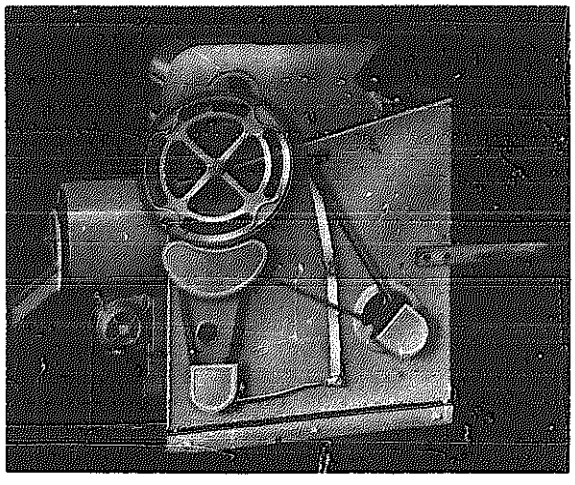
Because of the different sizes, shapes, and degrees of maturity of grain, no rice huller can hull every paddy completely in one operation. Any attempt to hull all of a paddy will result in excessive breakage. When a mixture of hulled and unhulled rice is fed into the hopper of separator, it glides down along the surface of multistaged, inclined wire screen and separates the rice into four kinds: (a) completely cleaned, hulled rice, (b) unhulled rice, (c) unripened and imperfect rice, and (d) broken rice with mud, sand, or dust. It is also used for sorting the polished rice for grading. It is made of hardwood and can be dismantled and folded down for storing. Wire screens of different sizes are furnished to meet varying needs. It will separate paddies at a rate

of about 70 bushels per hour and also grades brown rice.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka, Pref. 567 Japan

Heid Saat 6

The Heid Saat 6 seed cleaner produces unadulterated seed grain from all kinds of large and small seeds, such as wheat, rye, barley, oats, pulse, clover, vegetables, linseed, millet, and colza. The machine is of compact, all-steel construction and its design combines all the standard elements used in conventional seed cleaning: coarse sieves, sand or grading screens, air sifter, and trier cylinder. Suitable screens and indent cylinders are available for all varieties of crops. The Heid Saat 6 is equipped for drive by either electric motor or a handwheel. Weighing no more than 150 pounds, the machine can be trundled from place to place like a wheelbarrow by a single person. It has a 0.4 h.p. requirement and an output of 300 pounds per hour.



Heid Saat 6
Heid Ag

Heid Ag
Postfach 147
A-1015 Wien Austria

CeCoCo Bean Separator and Grader

This machine will automatically separate and clean beans from dust, grit, stone, mud, sand, seeds, or any other foreign matter and classify them into three grades—small, medium and large—by means of interchangeable screens. Of wood construction, the separator is available in four sizes:

Type	Hourly Capacity	Power Required
No. 1	50-60 bushels	½-1 h.p.
No. 2	40-50 bushels	¼-½ h.p.
No. 3	8 bushels	Hand
No. 4	12-16 bushels	¼ h.p.

CeCoCo Bean Cleaner and Separator

This unit is specifically for use with the red bean and other round-shaped beans. The input funnel is equipped to regulate an even flow of beans to the first separating device, which removes impurities, husks, and dust, and onto the second separating plate, which removes imperfect or immature beans. There are provisions for adjusting the machine to fit the specific bean being cleaned.

CeCoCo White Rice Cleaner

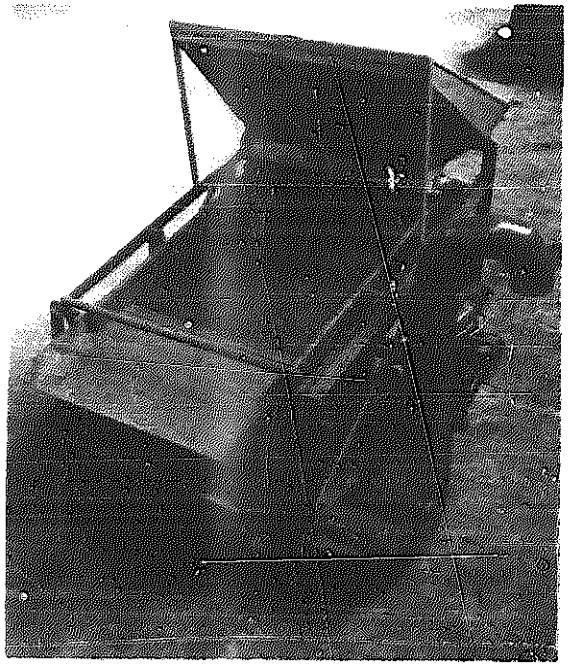
Using the difference in weight between grains and the accompanying impurities, this machine will separate rice from dust, sand, stone, grit, and other foreign substances. The machine is light; the heaviest of the four models weighs 110 kilograms. Also, it requires only 1/12 to ½ h.p. to operate.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka, Pref. 567 Japan

IRRI Power Grain Cleaner

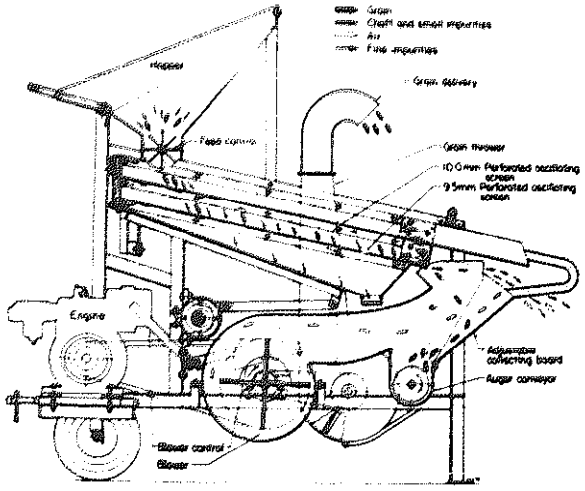
The Power Grain Cleaner uses rotary screens in conjunction with an air blast. This combination simplifies the design and permits extended exposure of a tumbling mass of grain to air, resulting in improved cleaning.

It is ideally suited for tropical countries and was designed particularly for rice mills, farms, warehouses, and experimental stations. The grain is cleaned by means of two concentric cylindrical screens. The inner screen retains large impurities but lets the grain through.



Power grain cleaner with 1.6 to 2.5 ton per hour capacity.
International Rice Research Institute

Smaller impurities like sand, dust, and weed seeds pass through the outer screen. This cleaner has an adjustable air opening for quality cleaning and an adjustable feeding rate. The three pulley settings result in approximate cleaning capacities of 1.6, 2.0, and 2.5 metric tons per hour by powering with a 1 h.p. electric motor.



Sectional View of Oscillating Grain Cleaner
International Rice Research Institute

International Rice Research Institute
Box 933
Manila, Philippines

Hindsons Seed Grader

This grader has a manually fed hopper with a 66-kilogram capacity. It has one high-speed electric blower run by a 1 h.p. motor. Two sieves can be used at one time, and four sieves are provided with the unit. Screens are available for almost all crops.

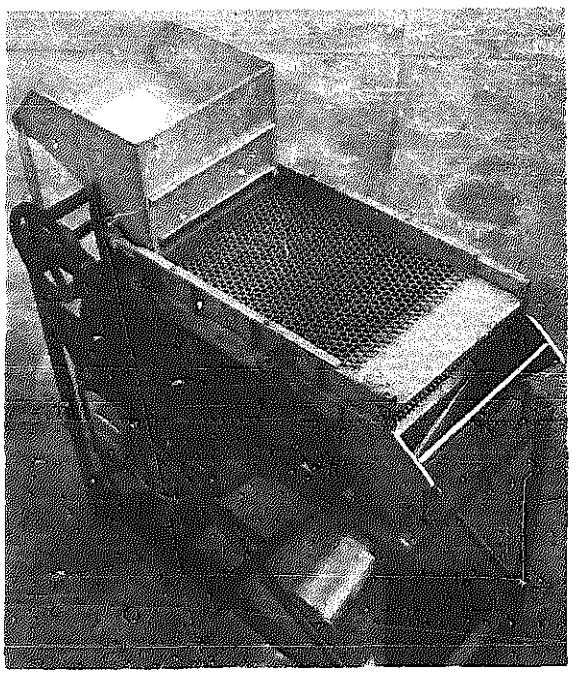


Hindsons Seed Cleaner
M/s. Hindsons Pvt. Ltd.

M/s. Hindsons Private, Ltd.
The Lower Mall
Patiala, Punjab, India

Improved Portable Grain Cleaner

The International Rice Research Institute has released an improved and simplified model of the small, oscillating grain cleaner for manufacture which has a 1-ton per hour capacity. It includes a 12-millimeter plywood body attached to a light-gauge angle iron frame and legs. An integral, eccentric drive and blower arrangement provide for both screen oscillation and air discharge to aid the grain cleaning. It is equipped with a small motor. Construction plans and sources of machinery are available from IRRI.

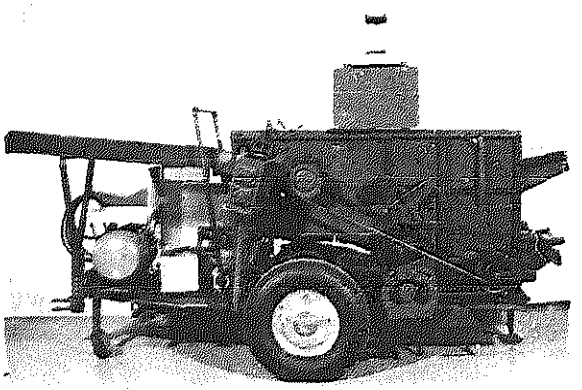


Improved Portable Grain Cleaner
International Rice Research Institute

International Rice Research Institute
P.O. Box 933
Manila, Philippines

Oilseed Thresher

This thresher, designed for a variety of oilseed crops such as safflower, flax, sunflower, and others, cleans by means of a straw walker, sieve, and fan combination. Spring-loaded crushing rolls and variable cylinder speeds from 200 to 1,200 rpm are used. The Engineering Research Service at Agriculture Canada found this to be one of the best research threshers because it will also handle a number of other crops, from field beans to alfalfa. It is, however, expensive to produce, and is not available commercially. Interested parties should contact:



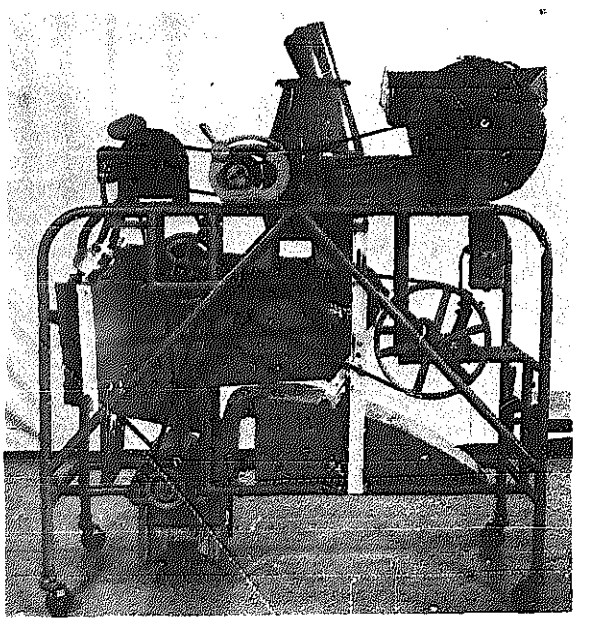
Oilseed Thresher
Agriculture Canada

Engineering Research Service
Agriculture Canada
Ottawa, Ontario, K1A OC6, Canada

Forage Plot Thresher

This small-capacity thresher, which cleans by means of a straw walker, sieve, and special aspirator fan, uses a radial rubber rub bar against a rubber mat for hard-to-thresh forage plants. The plans are available from the Engineering Research Service of Agriculture Canada, but only on microfilm. Inquiries about possible manufacture should be directed to:

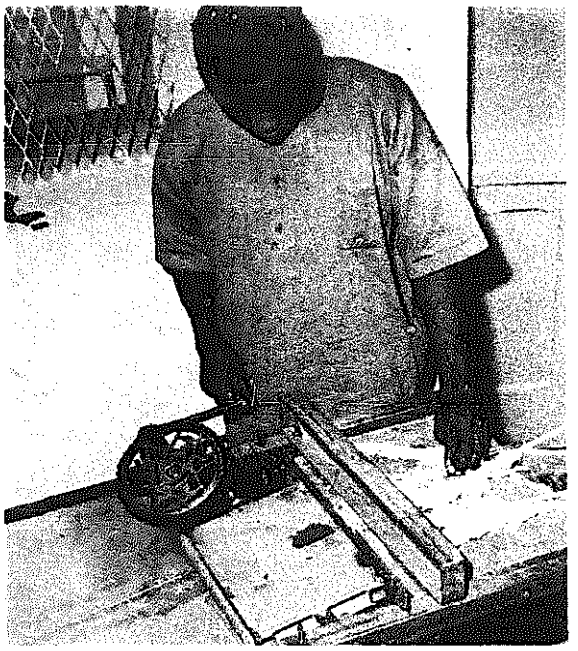
Engineering Research Service
Agriculture Canada
Ottawa, Ontario K1A OC6, Canada



Forage Plot Thresher
Agriculture Canada

Rotary Corn Thresher Plans

This guinea corn threshing machine, designed and built by the Intermediate Technology



Rotary Corn Thresher

workshop in Zaria, Nigeria, utilizes a bicycle crank and pedal as its main components. Plans are available from:

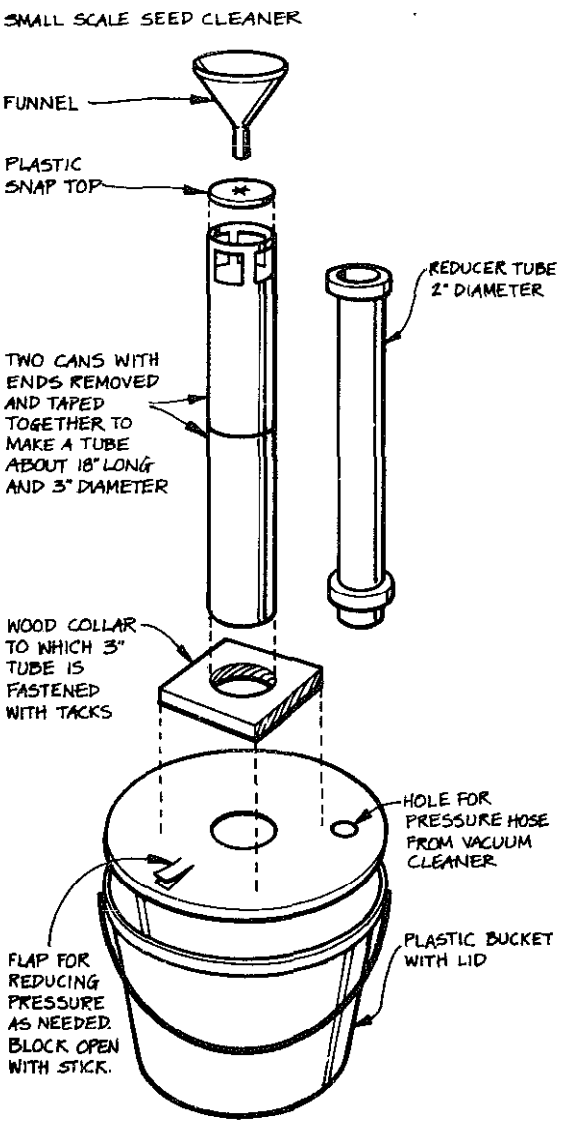
Intermediate Technology Publications, Ltd.
9 King Street
London, WC2E 8HN, England

Small-Scale Seed Cleaner

Farmers have been inventors for hundreds of years. As long as there are jobs to be done, individuals like Tim Sanford of Alexander, Maine, will be devising easy, inexpensive tools like his seed cleaner.

The cleaner, which uses a vacuum cleaner, a plastic snap-cover pail, a funnel, and a mailing tube, can clean over 100 pounds of seed per hour, though we wouldn't recommend it for anyone with over 1,000 pounds of seed to clean. "It works quite well, but not perfectly, for wheat and our seeds," Sanford explains.

To operate the seed cleaner, a steady stream of the grain to be cleaned is poured into the funnel. If it clogs, a thin stick will unclog it.



Adjust the airspeed (the vacuum should be blowing into the bucket) so the good seeds (the heavier parts) will be just heavy enough to escape being blown from the chaff holes at the top and will fall to the bottom. The inner tube (Sanford uses a cardboard mailing tube) can be made smaller to get more force from a vacuum cleaner with low pressure.

-8- Processing Equipment

GRINDING AND CRUSHING EQUIPMENT

In processing a crop for either human or animal consumption, it is generally necessary to reduce its size by either grinding or crushing it. This process is useful for correct feeding of livestock, since it increases the digestibility or palatability of the crop and also facilitates mixing it with other constituents of the feed. There are three basic kinds of mills used to crush or grind the harvest: (1) burr mills with either stone or steel burr plates, (2) roller mills, and (3) hammer mills. Before it is stored, the ground material is usually graded by sieving, as different sizes of material are used for feeding the various farm animals. For example, a coarser mixture is used for beef cattle, sheep, or laying hens, and a finely ground feed is more suited to high-producing dairy cows and young chickens. Oats, owing to the presence of fiber in the husk, are usually ground to a fine state for poultry feeding.

According to W. C. Krueger, author of an article entitled "Basic Principles Involved in the Design of the Small Feed Grinder," which appeared in the July 1927 issue of *Agricultural Engineering*, "the problem of feed reduction has always been of vital interest to farmers. From the time of the first horsepower burr mills to the largest present-day attrition mills, the progress in mill development has been towards faster, cheaper, and more economical grinding. Custom mills operated by waterpower or steam supplanted the use of the individual horse-operated mills. The development of the gas engine, however, resulted in a revival of the individual farm mill, improved and reduced in cost by this time."

Krueger goes on to explain that with the coming of electrical power to villages and country towns, custom feed-grinding enjoyed a brief revival. The new attrition mills produced a feed of better quality than that ground in farm mills, and farmers once again brought their feed crops into town for grinding. Later, when electricity was available to everyone, even rural dwellers, farmers began investing in electric motors to run their own mills.

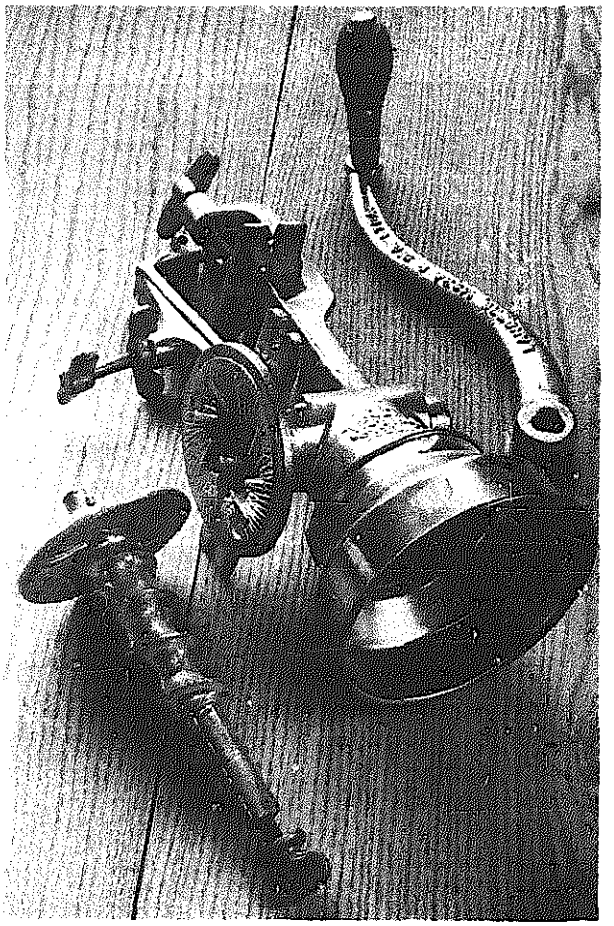
Today, most milling is done right on the farm. The self-sufficient small farmer needs a mill which will serve a variety of functions involving both the household and farm. He should seek long-term economy and durability while satisfying his every milling need.

A burr mill is generally a better choice than a hammer or roller mill if you will need to do fine milling for household flour. Hammer mills are quite popular on the farm for grinding animal feed, but they do not produce a uniform grind, and are therefore not appropriate for milling flour. They are rugged and can grind different kinds of dry material at one time into different textures. Probably the most expensive mills to buy, yet the cheapest to operate, are the roller mills. They put out a good-quality feed, produce little waste, have a high-production capacity and require little power.

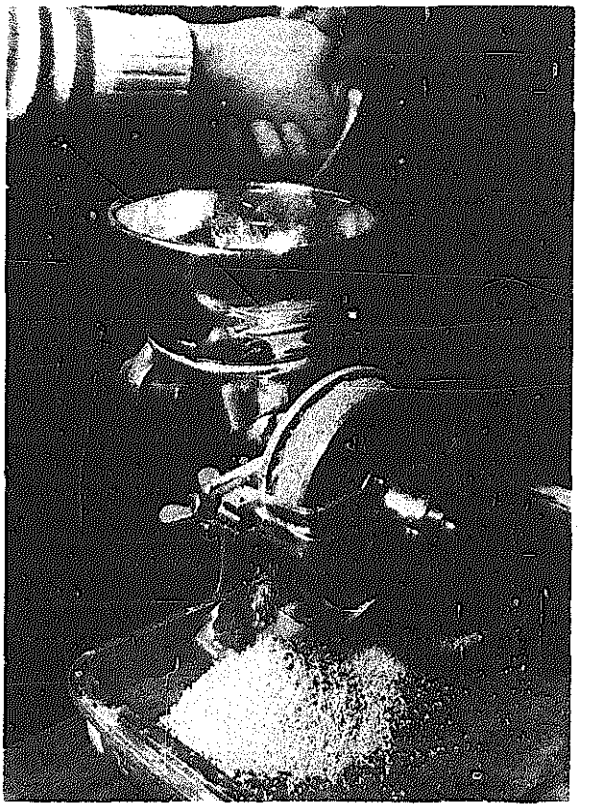
SMALL GRINDING UNITS

Many kitchen-scale grinding units are available for grinding both feed and household flour. Their output is considerably lower than that of mills specifically designed for farm use, but their versatility makes them worthy of consideration when only a few animals are kept on the farm.

Domestic mills are either hand-cranked or run by a small motor. Metal burr grinding plates are suitable for grinding and cracking grains, hulling some seeds, splitting peas, grinding coarse cereal, and making flour of a degree of fineness acceptable for bread. For a pastry-fine flour, stone mills are best. They can be used only with dry grains and seeds of 12 percent moisture or less. Moist seeds have a tendency to glaze the stones. If this happens, passing very hard winter wheat or very dry corn through the stones at their widest setting will clean the glaze away.



A cast-iron, steel burr mill disassembled to show feeding auger, stationary burr plate and interchangeable burr plate on auger.



Grinding pastry-fine flour with a stone burr combination hand mill.

But these mills are not made for certain jobs, and the manufacturers' guidelines should be followed carefully.

The most versatile type of mill is called a burr/stone conversion. One plate is a stationary burr which cannot be removed. The operator has the choice of interchanging a stone or burr for the other plate. A fine flour can be obtained from the burr/stone combination while the burr/burr combination will crack grains, handle oily seeds, and make nut butters.

Most electric mills designed for small-scale household use have stones. Often a hand crank is available in the event of a power failure.

SOURCES OF HAND MILLS*

All-Grain Mills

The H-1 Metal Burr plate mill is designed for cracking cereals; Model H-10 has stones and burrs. The grooved stones are designed for slow turning and will grind fine flour the first time through.

* For specifications and more detailed information on 75 household grain mills, write to *Organic Gardening* Readers' Service, 33 E. Minor St., Emmaus, PA 18049.

All-Grain Distributing Co.
3333 South 900 East
Salt Lake City, UT 84106

BH Grain Mill

This mill has a cast aluminum body with a chrome steel auger. Its artificial, adjustable stones will grind fine flour or coarse cereal.

Agri Resources
RR 3, Napanee
Ontario, K7R 3K8 Canada

Corona Burr Mill

This cast-iron burr mill grinds one pound of cereal per minute. It is adjustable for fine flour (which must be run through several times) or coarse cereal. The Corona Stone Mill with two stones is available for grinding fine flour the first time through. A conversion mill is also available.

Natural Health Appliances
P.O. Box 169
Meclean, Australia 2463

R & R Mill Co., Inc.
45 West First North
Smithfield, UT 84335

Village Equipment Suppliers
P.O. Box 2172
Lea, Papua, New Guinea

Red Chief Feed-Grinding Mill

The Red Chief, which can be used with all small grains and is especially recommended for poultry feed, grinds 1 to 2 bushels per hour. Spring tension regulates the fineness of ground material. Triplex and flat steel burrs are used in the process. The mill fastens to a box or barrel.

Cumberland General Store
Route 3, Box 479
Crossville, TN 38555

S.A.M.A.P. Cereal Grinder

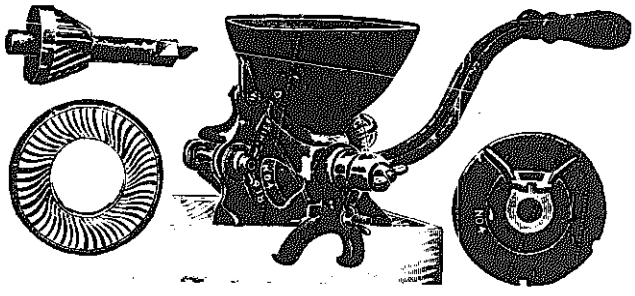
Also designed for specialized milling of very dry grains, the S.A.M.A.P. Cereal Grinder is a vertical-axis mill using natural stone granules embedded in stabilized magnesite cement. Fineness of grinding and the rate of grain feed between the stones are adjustable. Controlling the rate at which the grain is fed is a unique feature to the S.A.M.A.P. mill which allows the operator to determine the difficulty of his grinding stroke. The weight of this unit is 19¼ pounds (8.75 kilograms). (See photo on page 337.)

Miracle Exclusive, Inc.
16 West 40th Street
New York, NY 10018

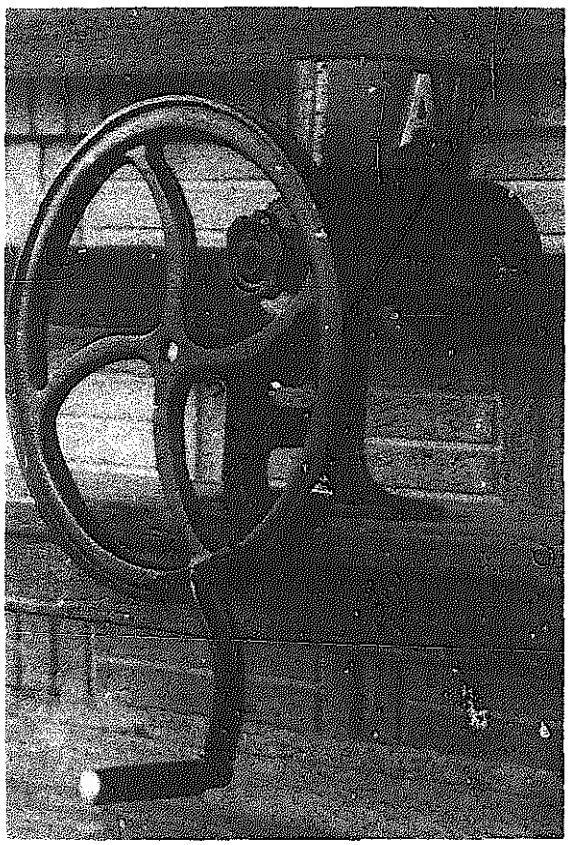
S.A.M.A.P.
B.P. Horbourg Wihr
68000 Colmar, France

Stone Miller

The AVI Stone Miller grain grinder is specifically designed to make it easy to grind wheat into fine flour in one grinding. It should be pointed out, however, that what is gained in ease is lost in speed. Although primarily designed for hand power, this mill can be efficiently run with an external power source. It is made of reinforced cast iron with gears providing a 2:1 reduction for easy grinding. The 18-pound, 16-inch diameter flywheel handle drives an auger which feeds grain between two 5-inch stones. The stone separation is adjustable and the hopper holds 4 pounds of grain. Total weight: approximately 55 pounds.



Red Chief Mill
Cumberland General Store



AVI Stone Mill

The American Village Institute
440 Meyers St.
Kettle Falls, WA 99141

Little Gem Hand Mill and Juicer

This is an adjustable cast-iron, stone, hand mill. Turn the handle to the left to grind grain, to the right to make juice.

Little Gem Mills
23655 S.W. Francis
Beaverton, OR 97005

O.B. (Quaker City) Steel-Stone Grinder

This model has two sets of metal burrs—coarse burrs for cracking grains and grinding oily grains and seeds, and sharpened burrs which grind flour from oily grains that would clog stone grinding surfaces. This company also carries the Victoria stone-burr combination mill. (See photo on page 337.)

Sterling H. Nelson & Sons, Inc.
525 South 500 West P.O. Box 1296
Salt Lake City, UT 84110

Victor Stone-Burr Mill

This cast aluminum and durable plastic mill has a stone grinding surface and a stainless steel screen to sift flour to a uniform texture. Pulleys are available to attach the mill to a motor.

Victor Mfg. Co.
8141 4th SW
Seattle, WA 98106

Little Ark Hand-Electric Stone Mill

This mill is designed to grind all dry grains and should not be used to regrind flour previously ground or to grind damp grains. It can be motorized, but the stones should be set at 150 rpm or less to avoid damaging them. A ⅓, ½, or ¾ h.p. motor can be used.

Retsel Corp.
Little Ark Division
McCannon, ID 83250

SOURCES OF ELECTRIC MILLS

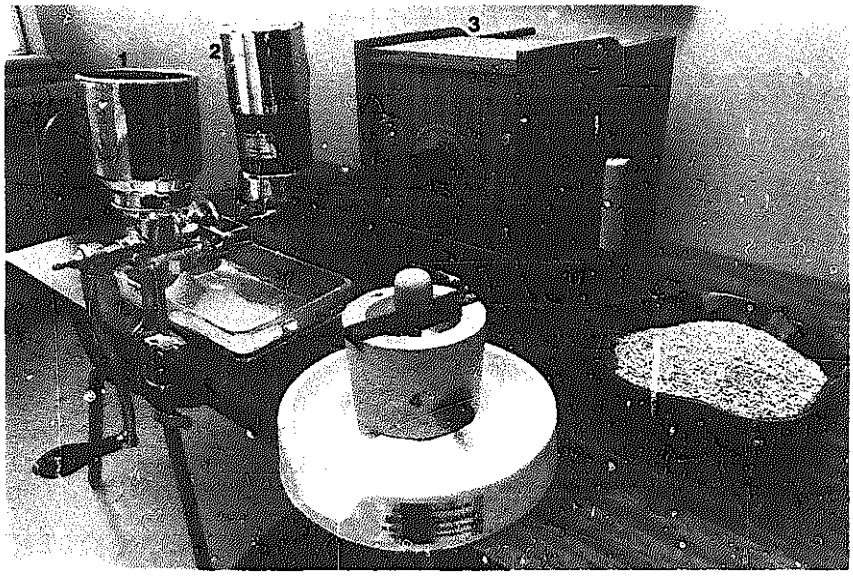
All-Grain

The All-Grain has a turbine-cooled air mechanism. The silicon carbide stones are placed horizontally inside a metal housing. There is a five-year unconditional guarantee on the mill, your choice of a ⅓, ½, or ¾ h.p. motor, and the stones. (See photo on page 337.)

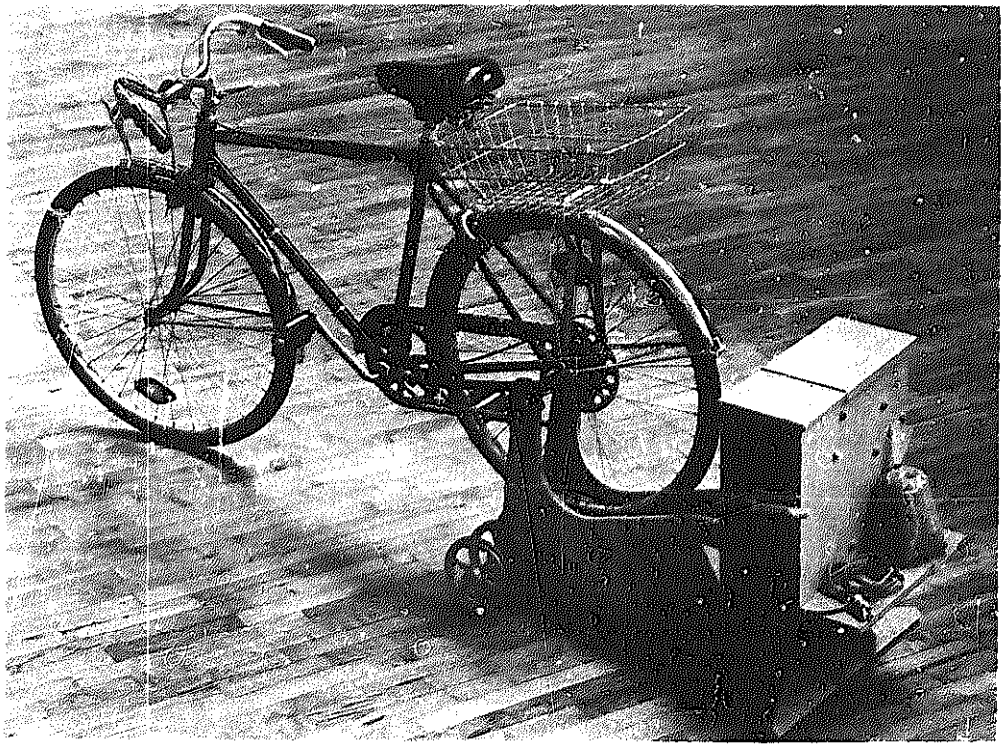
All-Grain Distributing Co.
3333 South 900 East
Salt Lake City, UT 84106

Lee Engineering Company Mills

This firm offers either fully adjustable grind or fine grinding mills. An automatic mechanism feeds the aluminum oxide grinding stones. The polyethylene hopper holds approximately 4 pounds of grain. Grinding rates for the ⅙ h.p. mill are 3 to 5 pounds per hour of fine flour, 20 to 25 pounds per hour of coarse meal. Rates for the ¼ h.p. mill are 6 to 10 pounds per hour for fine flour, 40 to 45 pounds per hour for coarse meal.



1) Victoria Combination Hand Mill. 2) All-Grain Power Mill. 3) Marathon Uni-Mill. 4) S.A.M.A.P. Hand Mill



Homestead Industries in California once made this power transfer unit to adapt their mill to pedal power. It is no longer available commercially but the technique is simple enough for the tinkering miller to duplicate. A wheel secured against the rear bicycle tire transfers power to a pulley which can operate any mill whose driving mechanism can be fitted with a pulley and run with a V-belt.

Lee Engineering Co.
2023 W. Wisconsin Ave.
Milwaukee, WI 53201

Marathon Uni-Mill

This unit has a particle board cabinet with a ½ h.p. motor and a direct-drive handle for

manual operation. The adjustable stones have a shear-slice grinding action which grinds 1 pound of flour per minute and 2 pounds of cereal per minute. (See photo on page 337.)

The Grover Co.
2111 S. Industrial Park Ave.
Tempe, AZ 85282

The Harvest Mills Mill

The spring tension on the stones in this mill prevents them from locking due to the heating of grinding, and it absorbs the shock from foreign materials entering the grinding area. The mill has a ¾ h.p. motor with a 1-year guarantee, stainless steel hopper and drawer, and an oak cabinet. It produces flour at a rate of 60 to 70 pounds per hour. A hand-crank adapter is provided.

KBL Enterprises
3471 South West Temple
Salt Lake City, UT 84115

Excalibur

This mill has a ½ h.p. capacitor-start motor with a ¾ h.p. motor optional. The ¾-inch birch cabinet is standard, but other woods are available as options. The 5- by 1-inch stones are fed by a 7-cup capacity hopper producing 42.1 pounds of fine flour per hour.

Excalibur Products
57711 Florin-Perkins Rd.
Sacramento, CA 95828

Golden Grain Grinder

The stainless steel inserts on this model crack the grain before it enters the stones, producing less grit in the flour and less wear on the stones. The self-cleaning stones produce up to 40 pounds of flour per hour. A ¾ h.p. motor and hand crank are provided.

Golden Grain Grinder
Division of Kuest Enterprises
Box 110
Filer, ID 83328

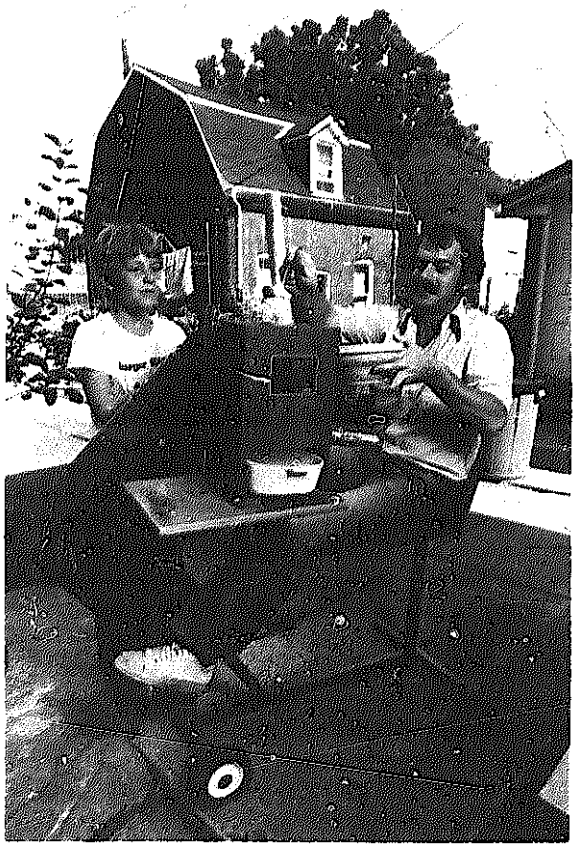
Little Gem Mill

A ⅓ h.p. motor gives the Little Gem a grinding rate of 25 pounds of fine flour per hour and 100 pounds of coarse meal per hour. The mill comes with a hand conversion kit and birch cabinet.

Little Gem Mill
23655 S.W. Francis
Beaverton, OR 97005

Miller Boy Mill

On this model, a ⅓ h.p. motor powers the tungsten-carbide shears which cut the grain before it is fed into the stones. The mill will grind approximately 36 pounds per hour. Two cabinets are available with different bin capacities.



The Miller Boy Mill seen here has been modified from electric to pedal power. The pedal power unit, called the Energy Cycle, is a product of Rodale Resources Division, Emmaus, Pa.

Magic Valley Industries, Inc.
405 Highway 30
Filer, ID 83328

Mil-Rite Stone Mill

The 5-inch adjustable stones of this mill are powered by a ¼ h.p. motor, for a grinding rate of 12 to 15 pounds per hour. Hand conversion is provided. The model carries an unconditional 2-year guarantee.

Romper Stone Mill

This mill grinds 3 pounds of flour per hour. Hand conversion is available.

R & R Mill Co., Inc.
45 West First North
Smithfield, UT 84335

Great Northern Flour Mill Kit

The tools needed to assemble this mill include a hammer, screwdriver, wrench, nails, and glue. The kit includes milling stones with a mounting arbor, ready-to-finish birch cabinet pieces, a Dayton ½ h.p., 3,450 rpm capacitor-start motor with cord and switch, a 17-cup capacity flour pan; a 6-cup capacity grain feed funnel, and all the necessary hardware and instructions. The stones are guaranteed for 10 years, and can be converted to hand- or bicycle-powered operation.

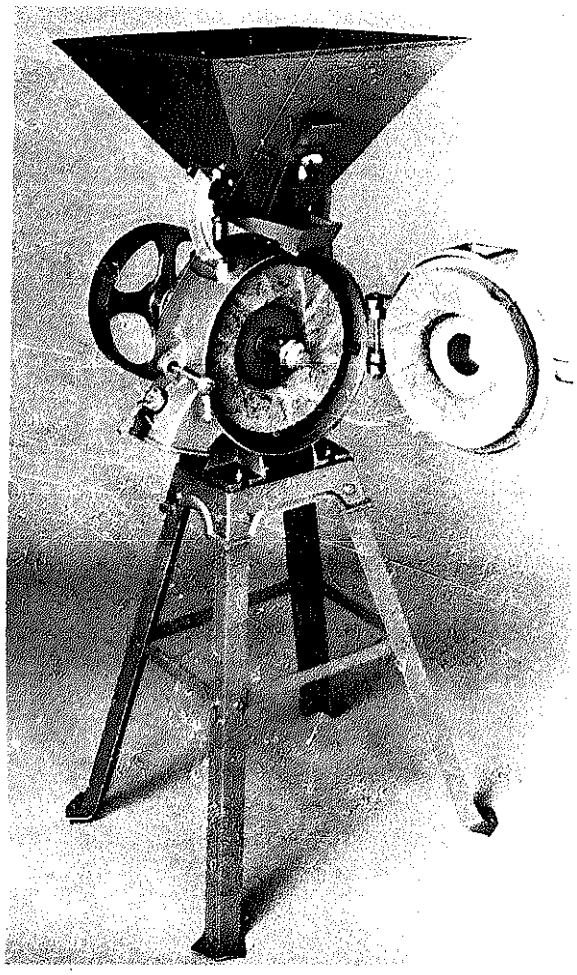
Great Northern Distributing Co.
325 W. Pierpont Ave.
Salt Lake City, UT 84101

FARM-SCALE MILLS

Burr Mills

The hand-operated grinding stone, the earliest grinding device used on the farm, somewhat resembled a mortar and pestle in form. It consisted of two pieces of stone roughly cut in the shape of flat discs. The top disc was rotated by hand over the stationary bottom disc, and the material to be ground was fed through the space between the two discs. The old-time grist mill driven by water, wind, or mule power is a good example of a mechanized version of the grinding wheel.

The modern burr-stone mill is a further development of the grinding wheel and is often referred to as an attrition mill, meaning a mill which grinds by friction. The burr mill consists of two disc-shaped stones with burrs or grooves cut into their grinding faces. The grain is fed at the center of the stones and is cracked without crushing as it passes toward the periphery. The stone discs have generally been replaced by chilled, cast-iron plates (hence the name plate mill) with corrugations or projecting cutting edges cast into the rubbing surfaces.



The stone plates of the Moderne Mill with grooves cut on their grinding faces. The pattern is designed wide and deep for cracking near the center where grain is first fed into the mill and gradually shallows to reduce the grain to a fine flour.
Renson Et Cie

The space between the plates is controlled by a spring-loaded, spacing screw, and the plates are usually corrugated on both sides to make them reversible. When starting a plate mill, the grain feed is blocked off and the spring pressure relaxed, leaving the plates at their coarsest setting. Once the mill is rotating at normal speed, the grain is fed into the mill. The plates are gradually forced together by tightening the spring until the desired texture is obtained.

This kind of mill is best suited for grinding meal and flour for household use since it grinds the finest and loses none of the whole grain. When set correctly, the tight hulls on barley and oats will come off in stone grinding. The ground material comes out as a flour and crushed hull mixture. The hulls, which now resemble flakes, can be sifted away. Steel-burr plates grind the entire kernel, making separation of hulls and grain much more difficult. Small, hand-operated barley pearlers are available to shatter the hull away from the kernel before the grain is milled.



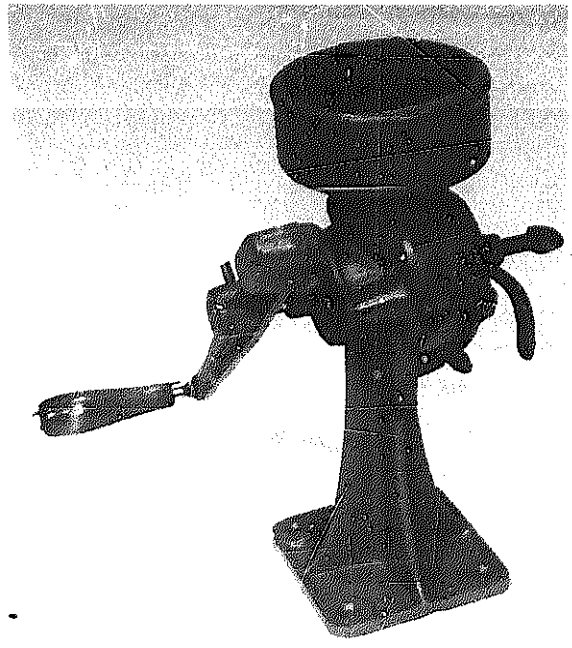
Among the weeds, a power-take-off burr mill about to be sold at an auction.

The main advantages of a burr or plate mill are relatively low speeds of operation (around 1,200 rpm), better adaptability for grinding texture than hammer mills, uniform grade of grinding, and fairly low power requirement. This is the farm mill best suited for kitchen use, since it grinds the finest and loses none of the whole grain. Disadvantages of a burr mill include: fast-wearing plates, the possibility of equipment being damaged by foreign objects like stone or metal fragments, a relatively high power requirement for finer grinding, and the possibility of damaging the plates when operating the mill empty, unless the pressure between the plates has been released.

NORTH AMERICAN SOURCES OF BURR MILLS

C. S. Bell Number 2 Hand Model

For dry grinding only, the No. 2 Model Hand Grist Mill can grind all dry, small grains, shelled corn, beans, peas, coffee, and even dried bones. The cone burrs are easily adjusted for a fine or coarse grind. The mill is furnished with a counterbalanced crank to help ease operation and allow a capacity of approximately 25 pounds

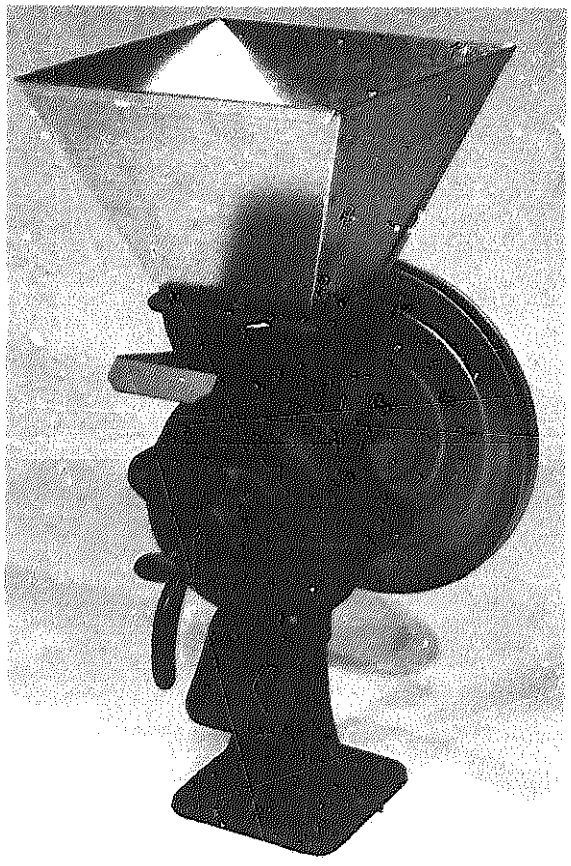


Bell No. 2 Hand Burr Mill
C.S. Bell Co.

per hour depending on the material being ground.

C. S. Bell Number 60 Model Power Mill

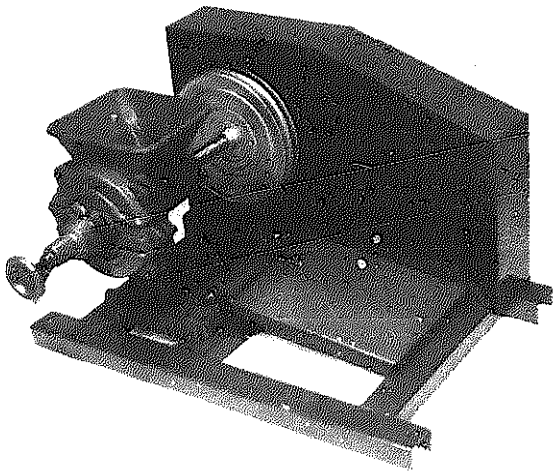
For dry grinding only, the No. 60 Model Power Mill is designed for grinding all small grains, shells, roots, bark, and salt. The unit is available with a set of coarse, fine, and extra fine grinding burrs to be operated by a 1 to 2 h.p. electric motor. A 3 h.p. motor is recommended for extra fine grinding. Depending upon the material being ground, the fineness of the grind, and the size of the motor, this mill has a capacity of 100 to 300 pounds per hour. Shipping weight: approximately 52 pounds.



Bell No. 60 Power Mill
C.S. Bell Co.

C. S. Bell La Milpa

La Milpa is a large, power grist mill which can handle wet or dry grinding of grain, soybeans, bananas, wheat, and tortillas at a rate of up to 1,400 pounds per hour. The 6-inch steel alloy burrs are adjustable for coarse or fine grinding and are fed with a large feed worm for maximum capacity. A 5 h.p. motor is recommended for hard-to-grind material to maintain high capacity; however, a 3 h.p. motor will do the job. Ready for shipment, the unit weighs 110 pounds without the motor.



C.S. Bell La Milpa Power Mill
C.S. Bell Co.

The above three models are available from:
C. S. Bell Co.
P.O. Box 291
Tiffin, OH 44883

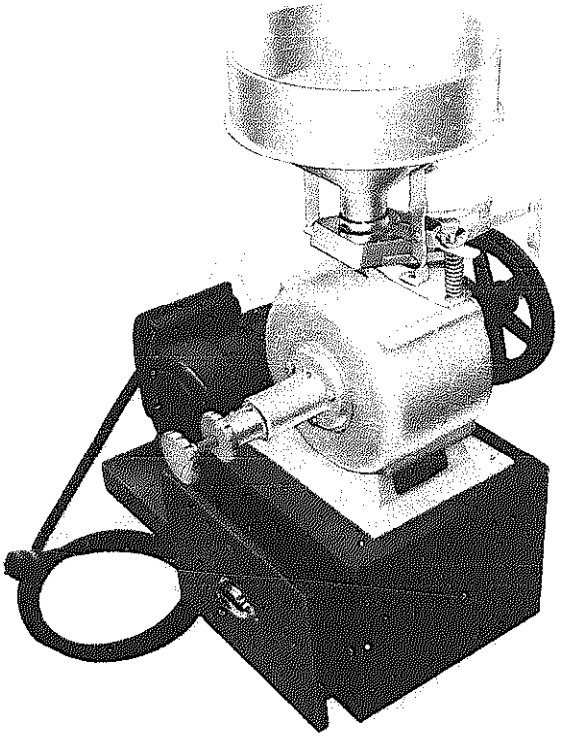
Speed King Cracker

Incorporating 14- to 16-inch burrs powered by a 5 to 10 h.p. motor to yield a 2 to 5 ton per hour capacity, the Speed King Corn Cracker cracks and grinds shelled corn, small grains, and other grindable granular products. Shipping weight: 450 pounds.

S-Crusher

Slightly larger than the Speed King Cracker, the Speed King S-Crusher can be driven with a 5 to 20 h.p. motor to yield a capacity from 2 to 15 tons per hour. It is designed for grinding and cracking ear corn and small grains, and for size reduction of other grindable products.

Both these units are made of cast-iron components with adjustable burrs. The product is



The Meadows 8-inch Stone Burr Mill
The Meadows Mill Company

cut rather than impact-ground, to eliminate undigestible particles.

Winona Attrition Mill Co.
1009 W. Fifth St.
Winona, MN 55987

Meadows Household 8-inch Stone-Burr Mill

Stones housed in cast iron are machined male and female for a precision fit. This mill is available with a wooden base and receiving drawer or mounted on a steel stand for bottom discharge into a bag. Eight-inch diameter stones are made of natural granite. Dry, free-flowing, small grain enters the mill at an adjustable feed-flow rate which requires no attendance.

Meadows Mill Co.
North Wilkesboro, NC 28659

INTERNATIONAL SOURCES OF BURR MILLS

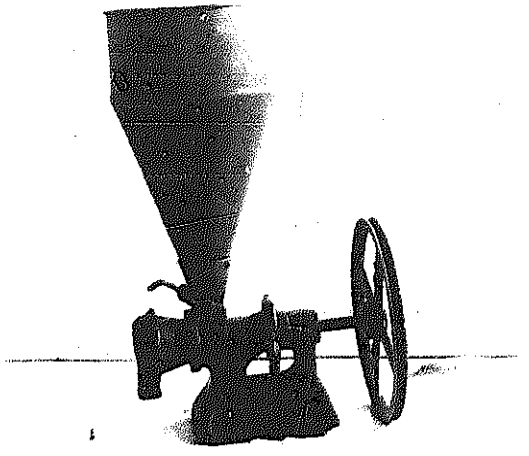
Dandekar Mills

Dandekar offers four vertical grinding mills employing 12- to 18-inch natural kurund stones for dry milling. The motor requirements range from 5 to 8 h.p. for capacities of 200 to 350 pounds per hour.

Dandekar Brothers
Sangli, Maharashtra
India

CeCoCo Hand Grinder Type D

This model is made of metal, with easily adjustable burr plates for fine or coarse grinding.



CeCoCo Hand Grinder Type D

It is adaptable for grinding flour from all kinds of grain and other materials such as rice, buckwheat, soybeans, and even fried fish! It has a grinding capacity of from 5 to 50 kilograms per hour, a hopper capacity of 10 kilograms, and a gross weight of 40 kilograms.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Diamant Domestic Mill

As with all burr mills, the Diamant is suitable for grinding any kind of grain, coffee, spice, or sugar, in wet or dry form. It is easily dismantled for cleaning without special tools and comes with a selection of plates for milling different materials. By hand, its output for grinding grains is approximately 70 kilograms per hour. The handle is mounted on a large flywheel to

ease operation. A groove in the flywheel supplies the option of operating this mill with a V-belt connection to an electric motor. The features of the Diamant mill typify the different features available on most hand mills.

A.B.C. Hanson Company A/S
Hauchsvej 14
DK-1825 Copenhagen V, Denmark

IN-TEC Equipment Co.
Box 123, D.V. Station
Dayton, OH 45406

Dunia Hand-Operated Grinding Mill

This small, hand-operated plate mill is constructed of all-welded steel and has been designed in Africa for grinding maize, wheat, coffee, and other foodstuffs. The front cover can be removed for cleaning and inspection by unscrewing three wingnuts.

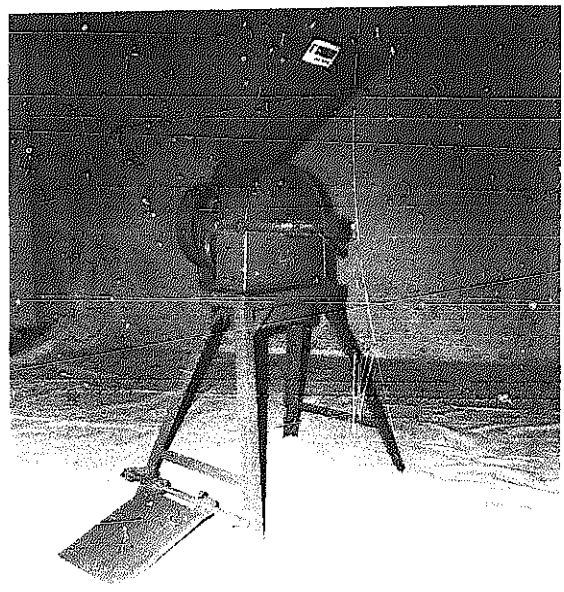
Ndume Products, Ltd.
P.O. Box 62
Gilgil, Kenya

Gaubert Mini-Grinder

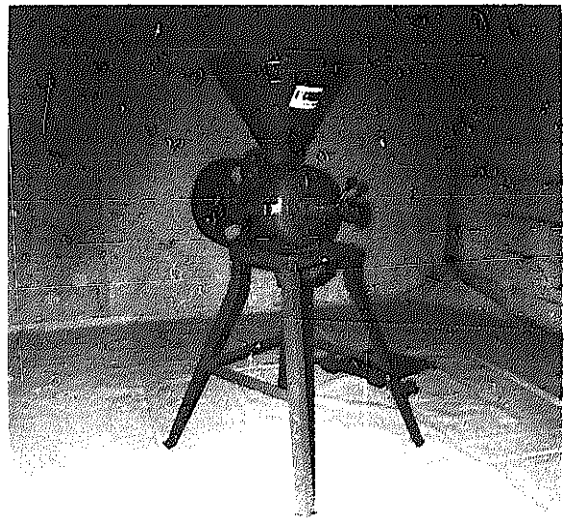
This French mill is designed for crushing wheat, barley, corn, millet, and coffee. It mounts on a table or workbench with two screws and has a 350-millimeter diameter wheel with a handle for manual operation; the flat wheel rim will accommodate a belt drive to a small electric motor. This mill has interchangeable 90-millimeter grinding wheels made of cast iron. An adjustment screw varies the separation between the wheels to provide for coarse or fine grinding.

Gaubert Senior and Junior 170 Mills

The Senior 170, a standing mill, offers an hourly production of 150 to 400 kilograms, depending on the fineness of the grind. It operates at a speed of 450 rpm, and contains 300-millimeter emery stones. The bearings are fitted with interchangeable self-lubricating bronze rings. Options for this model include a 3 h.p., 1,500 rpm electric motor or bearing, and a mounting for tractor drive. A smaller model, the Junior 170, with a reduced hourly production, is also available.



Gaubert Senior Mill
Ets. A. Gaubert

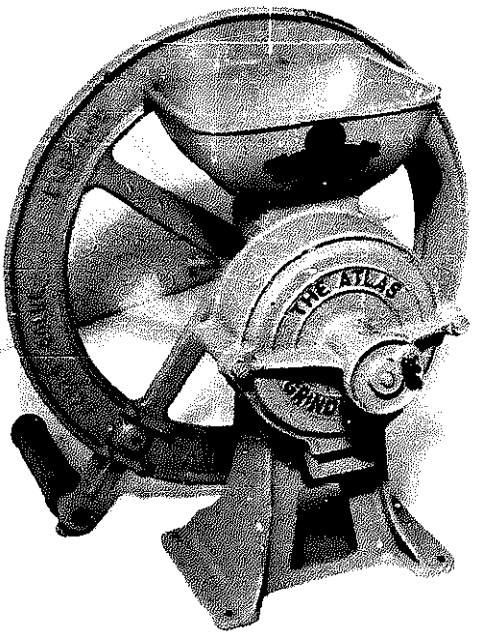


Gaubert Junior 170
Ets. A. Gaubert

Ets. A. Gaubert
16700 Ruffec
23 Rue Gambetta 23, France

Atlas Hand Grinding Mill

The Atlas Grinding Mill is suitable for grinding all types of dry grains, rice, coffee, spices, and some industrial products. It is made of cast iron and will grind from 7 to 9 kilograms



Atlas Grinding Mill
R. Hunt

per hour, depending on the fineness of the sample required and the speed at which the handle is turned. It is suggested that if a very fine sample is required, the meal be first ground coarsely and then ground again with the grinding plates at their closest setting.

Manufactured by:

R. Hunt & Co., Ltd.
Atlas Works, Earls Colne
Colchester, Essex CO6 2EP, U.K.

Distributed by:

Self-Sufficiency & Small-Holdings Supplies
The Old Palace, Priory Road, Wells
Somerset, BA5 1SY, U.K.

Superb Mill

The Superb burr mill is suitable for grinding all types of cereals. Its 270-millimeter plates are powered by a 5 h.p. motor for an output ranging from 230 to 270 kilograms per hour.

E.H. Bentall & Co., Ltd.
Maldon CM9 7NW
Essex, U.K.

Amuda Domestic Mill

Designed to be driven by a ½ h.p. motor, the Amuda Domestic Mill can grind all cereals finely at a rate of 18 kilograms per hour and kibble at a rate of 50 kilograms per hour.

Amuda Flat Plate Mill Number 1

A spring mechanism allows the plates to open and avoid damage if any hard substance enters this burr mill. It is designed for grinding all cereals, beans, spices, cocoa, coffee, and wet or dry corn. The rate of feeding the material to be ground into the milling chamber can be adjusted by regulating the shaker feed mechanism.

Both the Amuda mills are available from:
Rajan Trading Co.
P.O. Box 250
Madras 600 001, India

Diamant Vertical Mill

The Diamant Vertical mill employs stones of special composition available in 300-, 400- and 500-millimeter diameters for grinding dry cereals. A continuous feed flow from the hopper provides constant grinding. Diamant mills can be operated with motors ranging from 2 to 10 h.p. for outputs from 100 to 650 kilograms per hour. Another model, with steel-burr plates, has an output of 300 kilograms per hour with a 5 h.p. motor and 1,100 kilograms per hour with a 15 h.p. motor.

A.B.C. Hansen Comp. A/S
Hauchsvej 14
DK—1825 Copenhagen V, Denmark

Moderne Mill

The Moderne Mill has an agitator feed from a 35-liter capacity hopper into its 300-millimeter diameter grinding wheels. It has a screw adjustment for fineness of grinding. Its output ranges from 200 to 300 kilograms per hour when powered by a 4 to 5 h.p. motor. (See photo on page 339.)

Renson Et Cie
B.P. 14
59550 Landrecies, France

Type S Cereal Breaker

The Type S Cereal Breaker is suitable for crushing maize, rice, barley, beans, and poultry or cattle feed. It can be turned by hand or by a ¼ h.p. motor for a capacity of 40 to 60 kilograms per hour.

CeCoCo Feed Grinder

The Feed Grinder is an ideal machine for grinding corn, oats, soybeans, green peas, and wheat, and also for coarsely crushing fish meal and shells. Grinding plates are adjustable for either coarse or fine grinding. The double-faced grinding plates are reversible and interchangeable.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

R2 Grinding Mill

This model's 210-millimeter diameter, vertical millstones powered by a 2 h.p. motor provide an output of fine grist at 110 kilograms per hour for wheat, 80 kilograms per hour for barley, and 90 kilograms per hour for oats.

Iruswerke Dusslingen
7401 Dusslingen
Postfach 128, West Germany

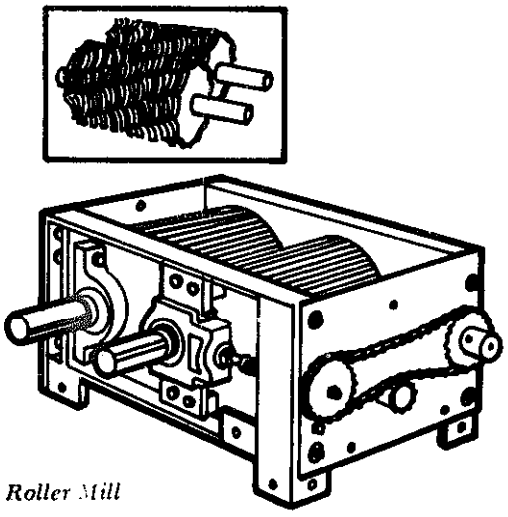
CeCoCo Multipurpose Grinder Model FG-61

The Star brand FG-61 feed grinder is designed to meet almost every grinding requirement. It will uniformly grind all types of dry grain such as wheat, oats, and barley, as well as peas and shelled corn, to any desired grist. The adjustable grinding plates are reversible and interchangeable. Two to four h.p. are required to operate at a capacity of from 8 to 13 pounds per hour. The unit weighs 132 pounds.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka, Pref. 567, Japan

Roller Mills

The ruggedness of a roller mill makes it the most expensive to purchase of the three types available. Grain is mashed between two serrated rollers which operate with the same action as a clothes wringer, so that the teeth on one roller fit the space between the teeth on the other. One roller is usually fixed and the other can be moved to adjust the clearance between the two.



Roller Mill

Roller mills are inexpensive to run and have a high capacity per horsepower because they reduce particles less than other mills. This mill's low power requirement does not provide it with the power to start with even a few kernels between the rollers—it must be completely clean to work. Its function in preparing animal feed is merely to break the hard, outer seed coat of a grain to make digestion easier and more complete. This process provides an important advantage over hammer mills, in that it keeps the percentage of fines (small particles, powder, and dust) to a minimum, producing less waste.

Grain can be hulled, cracked, crushed, or ground with a roller mill; the better models are even capable of producing a fine flour. Special crushing rollers will handle any kind of grain, wet or dry, and can be used to chop green corn and barley for making silage.

SOURCES OF ROLLER MILLS

Stationary Roller-type Feed Mill

The roller-crushing action of the Sears mill

minimizes dust waste. Two heavy-duty rollers (6 inches long, 9 inches in diameter) run on self-aligning ball bearings. This mill allows crimping or crushing of hard grain shells and makes feed more palatable than grain which is finely ground. It has a large 19 by 23½-inch, 16-gauge steel hopper. The hopper height, 32 inches, facilitates loading. The mill is furnished with a motor mount bolted to a stand and a 16-inch V-belt pulley. The overall measurement is 22 by 34 by 32 inches high. Requiring a 2½-inch motor pulley, this mill operates with a 4 h.p. gasoline engine or a 1½ h.p. electric motor for a capacity of 15 bushels of oats, 50 bushels of cracked corn, or 35 bushels of wheat per hour.

Sears, Roebuck & Co.
Farm and Ranch Catalog

W-W Roller Mills

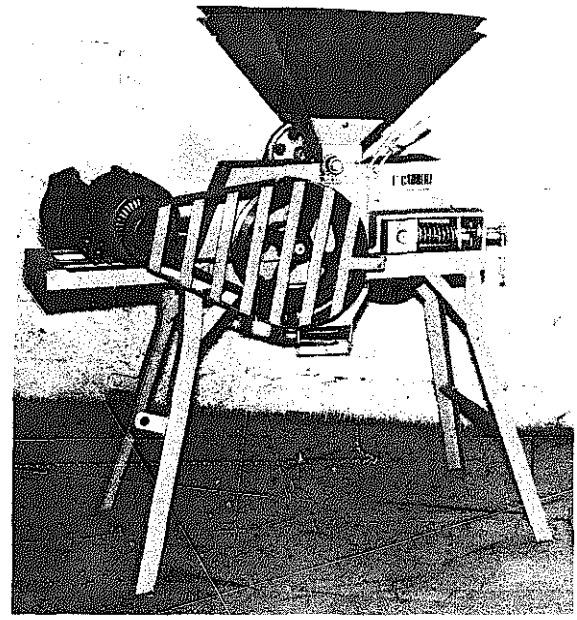
The W-W roller mill handles any type of small grain: shelled corn, oats, barley, sorghum grains, or wheat. It crimps, cracks, or crumbles, depending upon the degree of fineness desired. This mill has a heavy-duty construction, and the chilled, white-iron, 10-inch diameter rolls do not chip or peel and can be regrooved when necessary. A single control wheel handles all the adjustments. Roller sizes vary from 6 to 36 inches in diameter. Optional accessories are available.

Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204

Grain Rollers

Particularly of use in raising goats, cattle, and sheep, the Gaubert grain rollers come with two equal cylinders 300 millimeters in diameter and 130 millimeters in width. The grain-feeding mechanism is mounted in self-lubricating bronze rings powered by a 3 h.p. motor driving through a set of double pulleys and two V-belts, or through a one-flat, three-ply belt. Grains are rolled without crushing at a rate of 200 to 400 kilograms per hour, depending upon the grain.

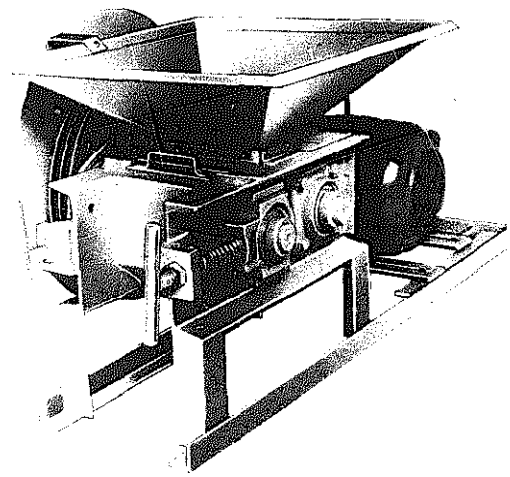
Gaubert S.A.R.L.
B.P. 24 16700 Ruffec
France



Gaubert Roller Mill
Est. A. Gaubert

6 by 6 Single Roller Mill

This 1 to 2 h.p. mill has solid white-iron rollers which are available without a corrugated surface for flaking, or corrugated for chopping, cutting, or crumbling. Its capacity for milling dry corn is 180 bushels per hour and 140 bushels per hour for high-moisture corn. Many other models are available in larger sizes.



Roskamp 6 by 6 Roller Feed Mill
Roskamp Manufacture Inc.

Roskamp Manufacture, Inc.
616 Grand Blvd.
Cedar Falls, IA 50613

BearCat Grain Roller Mills

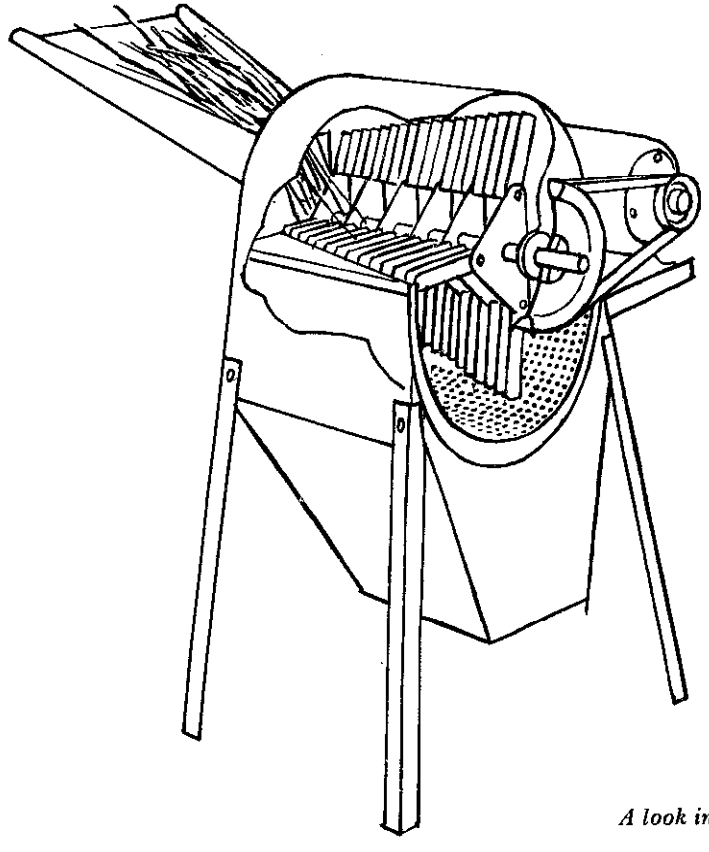
BearCat Roller Mills are available in a range of sizes between 5 and 30 h.p. and a number of power arrangements: stationary-mounted with electric motor drive; trailer-mounted with PTO drive; and stationary-mounted with PTO drive. An elevating auger feeder is available as an accessory. Rollers are one of three sizes: 10 by 12, 10 by 18, or 10 by 24 inches. BearCat also carries large hammer and burr mills.

Westernland Roller Co.
Hastings, NE 68901

Hammer Mills

The hammer mill is most often used today to grind feed for livestock and poultry. Instead of having burrs for the grinding process, the hammer mill employs rows of free-swinging, steel flails whirling at high speeds with an action similar to that of a leaf shredder. The impact of these hammers reduces the particle size. The screen under the hammers controls the fineness of the ground feed; the finer the mesh, the finer the feed. Hammer mills will grind all kinds of feed, even mixed grains, ear corn, and hay.

Large units are generally driven by the power take-off shaft of a tractor. A unit which requires 20 h.p. to drive produces 10 to 20 hundredweight of ground material per hour. The smaller hammer mills are popular for farm production of animal feed and concentrate mixes, and they are usually operated by an electric motor. The actual capacity depends on the rate of feeding, the speed of the hammers, the amount of power available, the kind of material being ground, fineness of grind, size of screen mesh, and the size of the mill. The capacity of a hammer mill for a given fineness and horsepower



A look inside a hammer mill.

is ultimately limited by the size of the grading screen.

The main advantages of a hammer mill are its simple construction and low replacement cost for spare parts, availability in a large range of sizes, durability of hammers combined with no reduction of efficiency during their lifetime, and there is little chance of damage from hard foreign objects like stones or from empty running of the machine. The main disadvantages are an initial high cost, high power requirements, inability to produce a uniform grind, and production of a high percentage of fines.

Though a hammer mill will not produce a uniform grind, some people feel that it produces a satisfactory flour if a fine enough screen is used during milling and the material is sifted afterwards. Hammer mills are used for a number of other functions besides grinding feed—primary seed cleaning, for example. The C. S. Bell Company has successfully used their hammer mill for such homestead tasks as processing garbage for compost, grinding wood and bark for mulch, and even shredding paper for worm-farm bedding.

NORTH AMERICAN SOURCES OF HAMMER MILLS

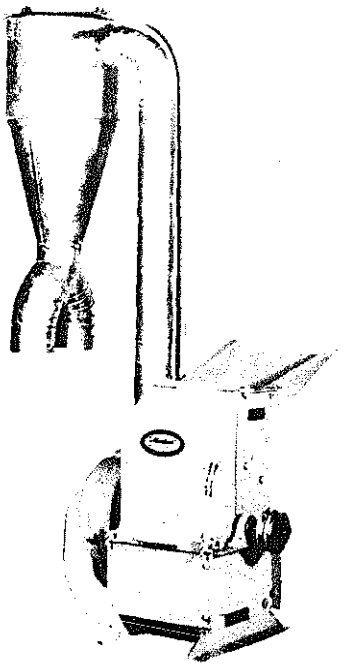
Sears Hammer Mill

The Sears 10- and 17-inch hammer mills offer rapid handling of any dry feeds such as wheat, oats, barley, ear and shelled corn, as well as roughages like hay and stalks. With 60 hammers, the 10-inch mill runs from a 10 h.p. tractor power take-off (PTO). The larger 17-inch mill requires a 15 h.p. PTO to operate its 80 hammers.

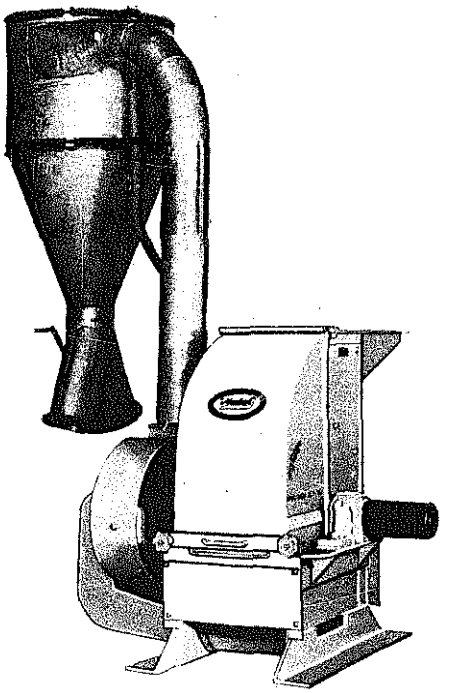
Sears, Roebuck & Co.
Farm and Ranch Catalog

Meadows Number 5 Hammer Mill

The Meadows No. 5 hammer mill is designed for farm and specialty use. It has a V-belt drive to 24 hammers from a 5 to 10 h.p. motor. The screen measures 9 by 17 inches, and the unit employs a 4-inch fan. Shipping weight is approximately 280 pounds. Meadows also manufactures three other mills with horsepower requirements ranging from 20 to 65.



The Meadows Mill No. 5 Mighty Marvel, requiring 5 to 10 h.p. The Meadows Mill Co.

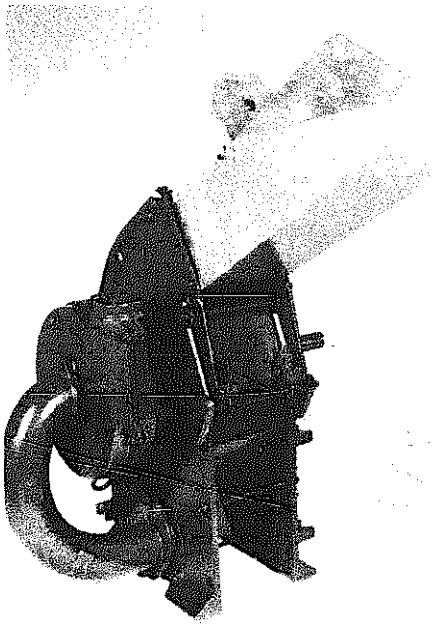


The Meadows No. 25 Trojan hammer mill requiring from 20 to 65 h.p. The Meadows Mill Co.

Meadows Mills Co.
West D St.
North Wilkesboro, NC 28659

C. S. Bell Hammer Mills

The Bell hammer mills are available in three sizes: No. 10, with a 6-inch width; No. 20, which is 9 inches wide; and No. 30, which is 12 inches wide. All are available with or without feed table; some have a blower discharge, others a bottom discharge. All models perform a variety of tasks.



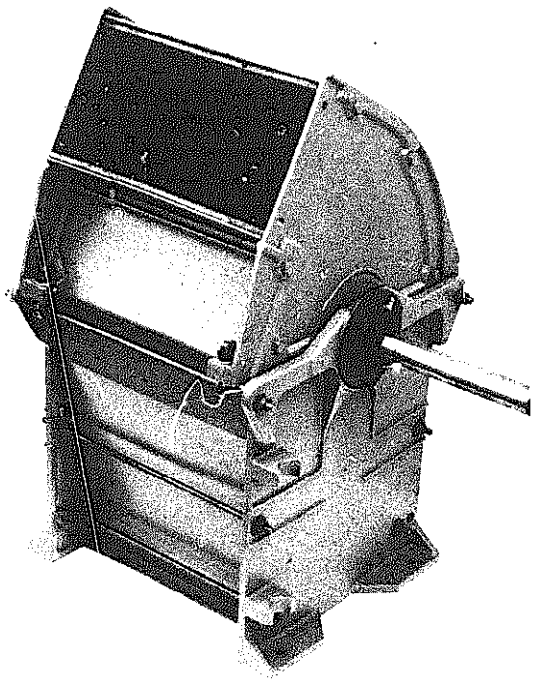
C.S. Bell No. 10 Blower Hammer Mill
C.S. Bell Co.

C. S. Bell Co.
P.O. Box 291
Tiffin, OH 44883

Viking Electric Mills

The Viking electric mill's hardened steel hammer blades, which are mounted directly on the motor shaft, turn 3,600 times a minute within the full-circle screen, converting the grain kernels to correctly sized ground feed.

Viking mills are available in 1, 7½, 21, and 51 h.p. motor sizes and can mill a range of perforations from 1/16 to ½ inch. Capacities vary according to the items being milled, the perforation size, and the size of the motor. The 1 h.p. unit can mill 375 pounds per hour with a ⅛-inch mesh screen.



C.S. Bell No. 30 Bottom Discharge Hammer Mill.
C.S. Bell Co.

Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204

Seedburo Equipment Co.
1022 W. Jackson Blvd.
Chicago, IL 60607

W-W Hammer Mills

W-W hammer mills have a Star Cylinder design that functions as a flywheel to reduce power requirements without sacrificing capacity. Spécial heat-treated reversible hammers, hard surfaced, always maintain a cutting edge. This mill is available in a range of sizes up to 150 h.p. The screens, which are easily changeable, are available with perforations ranging from 1/32 to 2 inches. As an option, this mill can be provided with a dust collector and a 20-foot pipe (without bagger). Gooseneck models are available where floor space is limited. Pulleys, sheaves, master

baggers, feed tables, PTO drive, and direct motor drive can also be obtained.

Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204

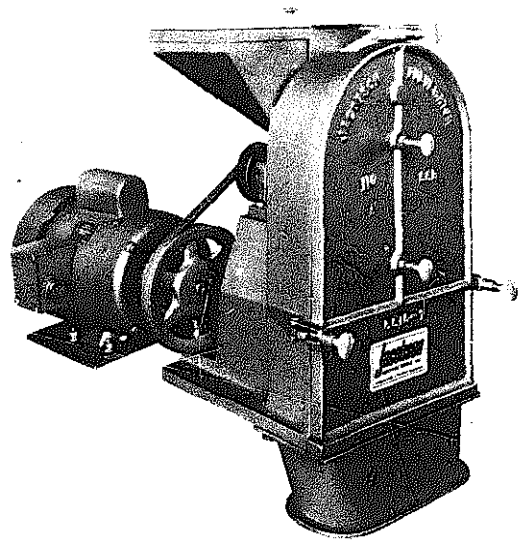
Model MG Hammer Mill

The Model MG hammer mill has a 15-inch wide throat and can be powered by a 5 to 30 h.p. motor. It is used to pulverize or reduce a wide variety of industrial materials including chemicals, plastics, grain, and dyes. It is also used as a finisher to smooth out a mixed product before bagging or final delivery. Direct-drive or belt-driven, this hammer mill can be mounted directly over the inlet or discharge point of a horizontal or vertical mixer in order to pulverize material before mixing or to smooth out mixtures after they are blended.

The Duplex Mill & Mfg. Co.
Springfield, OH 45501

Jacobson Models 66 and 88

Models 66 and 88 laboratory-size pulverators are belt-driven to provide a choice of grinding characteristics. They can be arranged to discharge into a bin, conveyor, or sack. Cast aluminum and steel construction assures resistance to corrosive materials. Featuring easy cleaning and a quick screen change, Models 66 and 88 have rigid hammers and adjustable feed gates and are available in two sizes, ¾ and 1½ h.p.



Jacobson's new lab model Full Circle Pulverator hammer mill, Model 66-B.
Jacobson Machine Works, Inc.

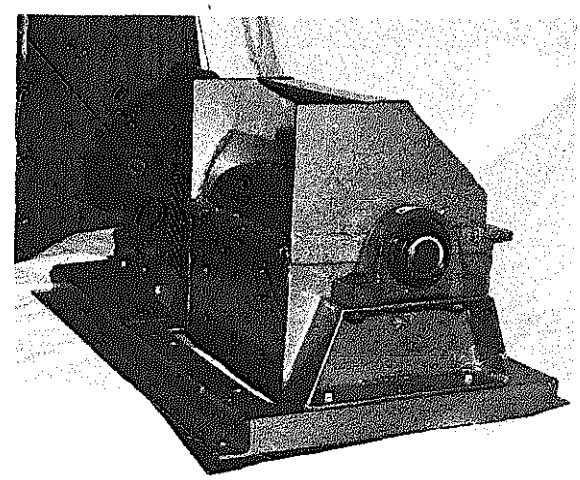
Jacobson Models 120 and 160

The Models 120 and 160 utility pulverators are generally used for moderate-capacity installations of a wide variety of free-flowing materials. Of standard welded-steel construction, they are also available in stainless steel, if required. The feed hopper is equipped with a slide gate for controlled feeding. These mills are available in either belt- or direct-drive, and with power requirements ranging from ¾ to 200 h.p.

Jacobson Machine Works, Inc.
2445 Nevada Ave. North
Minneapolis, MN 55427

Speed King Hammer Mills

Speed King hammer mills are high-capacity, impact grinding machines which come in seven sizes. They have hinged hammers and screen sizing. Other features include changeable wear plates, feeders, auger discharge, blower and pneumatic discharge, and other special features to suit the customer's needs. Horsepower re-



Winona No. 1008 Hammer Mill
Winona Attrition Mill Co.

quirements range from 1 to 5 for capacities from 12 to 100 cubic feet per hour.

Winona Attrition Mill Co.
1009 W. Fifth St.
Winona, MN 55987

INTERNATIONAL SOURCES OF HAMMER MILLS

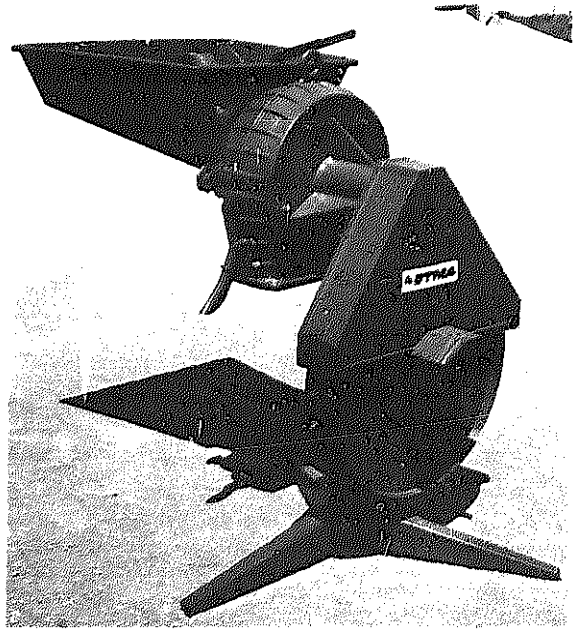
CeCoCo Model HM-10, Type S

The power requirement for the model HM-10 ranges from 7.5 to 10 h.p. to provide an hourly capacity of 650 kilograms of corn or 500 kilograms of dried hay. Type S requires a ¼ h.p. motor to yield 40 to 60 kilograms per hour of crushed cereals, beans, and most other material going into animal feeds.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Hammer Mills Model MF

This model comes with three screen sizes: 100, 120, and 150 millimeters, for three units with a combined power requirement ranging from 20 to 70 h.p. The smallest unit has a capacity of 200 to 300 kilograms per hour for cereals.



OTMA Hammer Mill Model MF
OTMA

OTMA
06018 Trestina Di Citta Di Castello (PG)
Italy

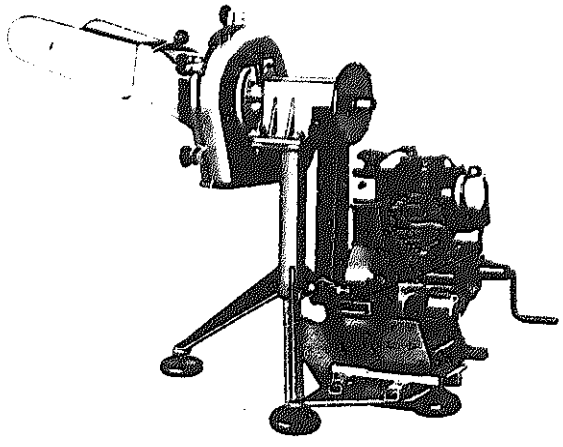
Vulcano Mini

The Vulcano Mini can work with knives or hammers or both. It is mounted on a column, has three fastening points for hitching to a tractor, and is available with an electric motor option. With a minimum power requirement of 15 h.p., it will mill from 500 to 1,500 kilograms of grain per hour. Larger models are also available.

F. Lli Deidone
Villafranca Verona
via a. messedaglia, 20, Italy

Funcor Fodder Grinder

This unit is specially designed for grinding many types of materials for a more complete use of animal foods. It grinds both green and dry fodders, corn cobs, oyster shells, straw, grains, and other feed materials. The unit calls for 5 h.p. and is available with either a tractor PTO link or a diesel engine. Milling size is adjustable and capacity varies accordingly.



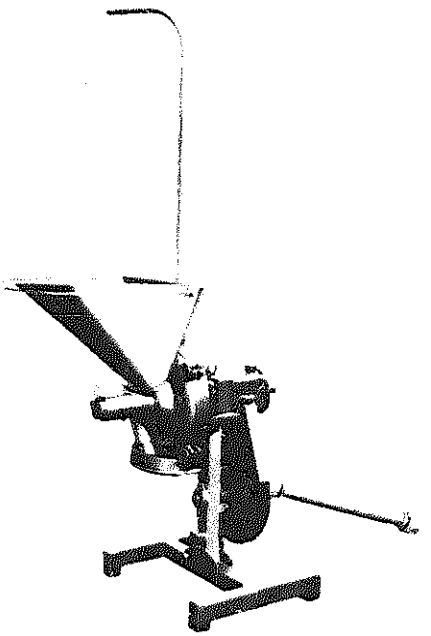
Funcor Fodder Grinder with Mounted Motor
Funcor Maquinaria Agricola

Funcor Hammer Grinder

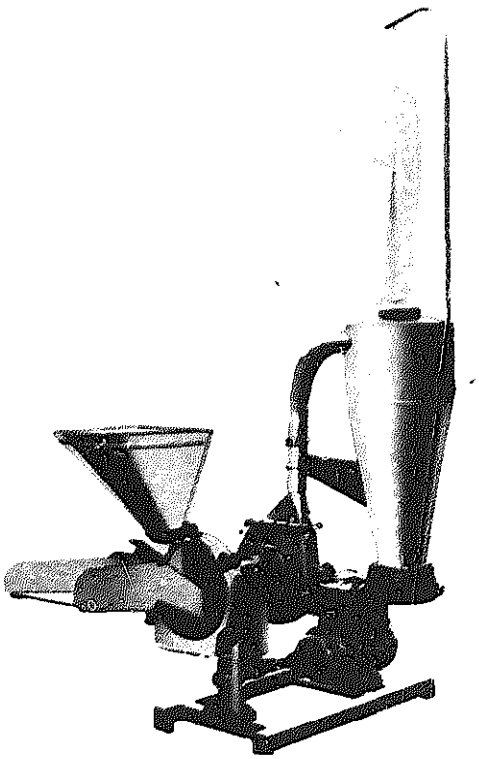
This is a 5 h.p. machine for grinding and milling all types of grains.

Funcor Combined Grinder

This machine combines the operations of



Funcor 5 h.p. Hammer Grinder with Tractor PTO Connector
Funcor Maquinaria Agricola

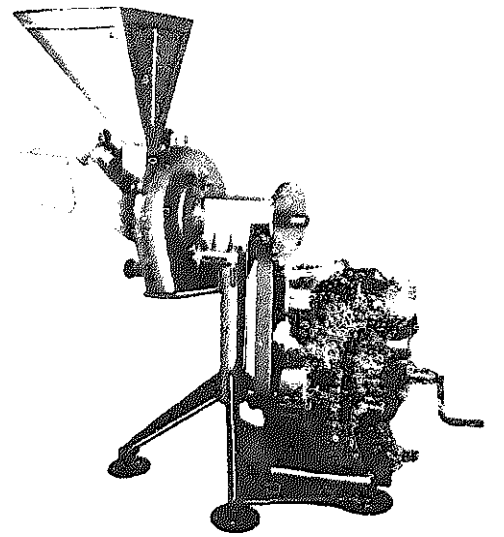


Funcor Combined Grinder with Tractor PTO
Funcor Maquinaria Agricola

the Fodder Grinder and Hammer Grinder, and it can mill all kinds of grains, green and dry fodders, corn cobs, bagasse, and straw. It also has a 5 h.p. motor.

Funcor Hammer Grinder Model-A

A feeding hopper on this model can be adapted for grinding dry fodder. This larger unit has an 8 h.p. requirement. It grinds all types of grains and dry fodders, is provided with a collector-bagger cyclone, and can be joined to one or two mixers for the complete preparation of the compound fodder.



Funcor Hammer Grinder Model A with Gasoline Motor
Funcor Maquinaria Agricola

The above mills are manufactured by:
Funcor Maquinaria Agricola
Elorrio (Vizcaya)
Spain

Nogueira Disintegrator

The Nogueira Disintegrator is a versatile machine, useful for either dry or green products. It cuts sugar cane, grass, boughs, roots, and tubercles, grinds corn with husk and cob, rice straw, corn stalks, and all sorts of grain. It can produce coarse, medium, fine, and extra fine cornmeal without heating the meal. It is available in three sizes with electric motors ranging from 5 to 10 h.p., and will produce cornmeal at rates ranging from 60 to 200 kilograms per hour.

Irmaos Nogueira S.A.
Avenida Ipiranga, 1071—10 Andar
Salas: 1001 4, Sao Paulo, Brazil

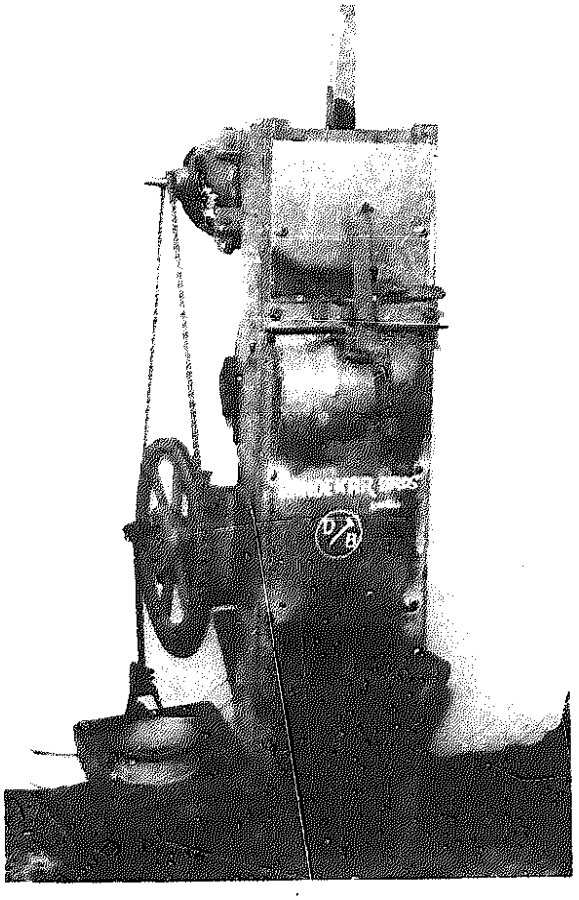
Tonutti Models 70, 100, 120, 150, and 200

Tonutti makes five models of hammer mills of differing power requirements and capacities. They are all designed to handle corn cobs, barley, and grains. They can be powered by electric motor or tractor PTO.

Tonutti s.p.a.
Remanzacco
33047 UD 063, Italy

Dandekar Pounding Machine

This unit is designed for pounding, not grinding, for the specific purpose of maintaining flavor in pulverized, pungent dry spices. No detailed specifications were available in English.

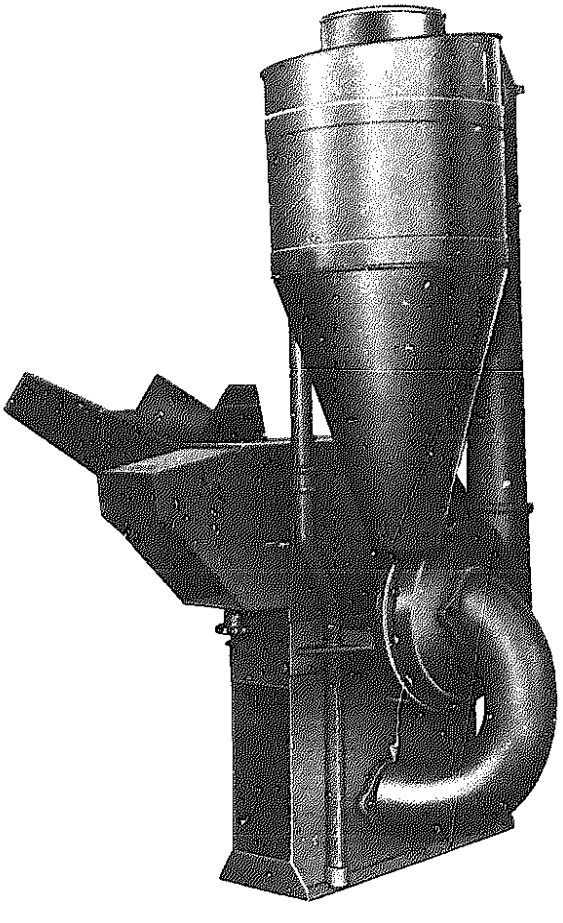


Dandekar Pounding Machine
Dandekar Brothers

Dandekar Brothers
Shirajinajar Factory Area
Sangli, Maharashtra, India

Jumil Model 6 Hammer Mill

The Jumil Model 6 is constructed of sheet metal and is powered by a 10 h.p. electric motor. The top part of the disintegrator is removable, which facilitates changing sieves and checking and changing knives and hammer rotation. Available equipment includes three types of sieves—one type for regular cornmeal, one for corn grits, and one for whole grains. Large, perforated sheets are used when chopping sugarcane, and a smaller sheet is used when pul-



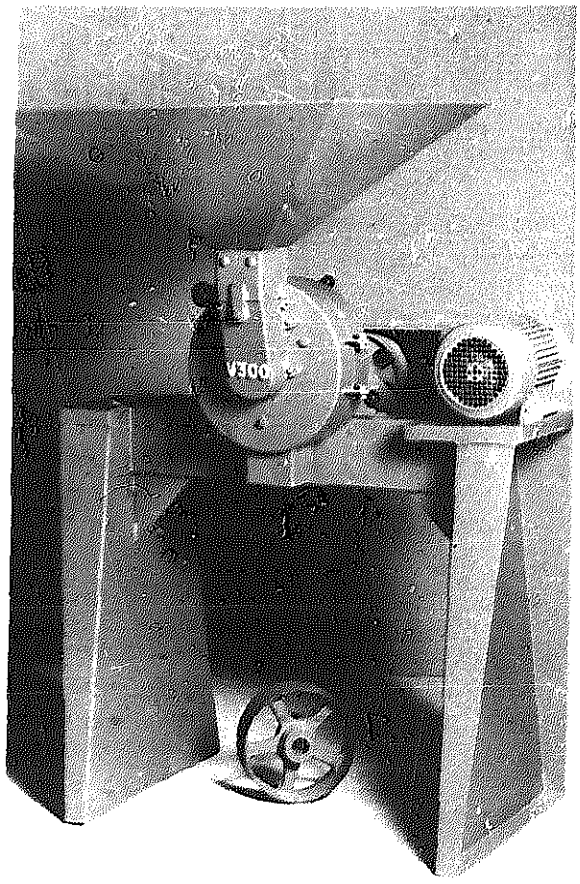
Jumil Hammer Mill
Jumil

verizing. The extra-reinforced flywheel, welded directly to the shaft, has two chopping knives and four hammers, and is made from a special steel to chop or pulverize as required. The machine pulverizes dry materials such as corn stalks with cobs, corn cobs with or without shucks, manioc, soybeans, and other dry fodders. It also pulverizes green fodders such as sugarcane, sorghum, pumpkins, and napier grass.

Justino De Morais, Irmaos S/A
Industria, Comercio e Importacao
Rua Ana Luisa, 568, Batatais-SP, Brazil

Champenois Hammer Mill V300

This French mill has a capacity ranging from 300 to 400 kilograms per hour for grains.



Champenois V300 Hammer Mill
Champenois

Champenois
Chamouilley
52170 Chevillon, France

JUICE PRESSES

Homemade fruit juices, fruit butters, cider, vinegar, wine, brandy—these are all good reasons for including a juice press on the list of tools that belong on a small, self-sufficient farm. Designs for juice presses consisting of five basic components—grinder, press, framework, juice-funneling system, and catch basin—are available from various companies as plans, kits, and fully constructed units. Use of the juice press need not be confined to that short time in autumn when cider appears on roadside stands. Fresh cider can be made as long as your supply of apples lasts in cold storage. Outside of apple season, the juice press is ready to go to work just as the blueberries, strawberries, cherries, peaches, and pears come into season to make fine homemade juices, jellies, and wines.

The single most important element in juice extraction is the efficiency of the grinding mechanism in turning the fruit into pulp. For maximum yield, every cell should be crushed. The press itself is only responsible for squeezing the juice from ruptured cells and does little to whole fruit. For this reason, grinders can be acquired separate from the pressing mechanism and framework.

A sharp, stainless steel-bladed roller is needed to cut through the tough skins of apples and chop them into pulp. Softer fruits like grapes and berries require less chopping. The squeezing action of cast-iron, ridged rollers does an adequate pulverizing job on these softer fruits. Both hand-operated and motorized crushing rollers are available. The best hand grinders have a flywheel and a three- or four-to-one gear ratio for the handle to give momentum to and take the rough spots out of the stroke.

The pressing plate can be driven by a hand-cranked press screw, a hydraulic jack, or even a car bumper jack. It is important that the framework of the press be rugged, and it is usually made of cast iron or rigidly constructed hardwood. After the fruit is crushed, the pulp is

wrapped in cheesecloth and placed either inside a framework of vertically arranged wooden slats or on press trays composed of horizontal slats. The pressure exerted by the press sends the juice through the grooves in the framework to an exiting funnel.

Small Home-Built Juice Press *

This small juice press can be constructed from fairly easy-to-find discarded materials, the most important of which is an automobile bumper jack to act as a pressing mechanism. No grinder is provided on this unit, but apples may be satisfactorily pulverized with a kitchen food grinder before pressing.

Three pounds of ground fruit can be pressed at one time. Wrapped in cheesecloth, the pulp is placed inside a strong-framed press box. Routered grooves lead to exit holes which allow the juice to drain to a pan below.

MATERIALS NEEDED

Wood

1 piece 2 x 12 x 4 feet	or	**Bench:** 1 piece 2 x 12 x 36 inches **Press:** 1 piece 1½ x 7¼ x 8 inches (act. meas.)
1 piece 2 x 4 x 10 feet	or	**Legs:** 4 pieces 2 x 4 x 11 inches **Uprights:** 2 pieces 2 x 4 x 34 inches
1 piece 2 x 4 x 8 feet	or	**Crossmembers:** 4 pieces 2 x 4 x 19 inches **Mounting blocks:** 2 pieces 2 x 4 x 6 inches
1–2 feet x 4 feet sheet ¾ inch ext. plywood	or	**Juice box:** 4 pieces 8 inches x 9¼ inches
1 piece 1 x 1 x 2 feet	or	**Cleats:** 2 pieces 1 x 1 x 11¼ inches 2 pieces 1 x 1 x 10 inches

Hardware

16d nails
Glue
8d nails
6d nails
3–4½" x 5/16" bolts w/nuts
8–5/16" ID fender washers
4–6" x 5/16" bolts w/nuts
Enamel paint

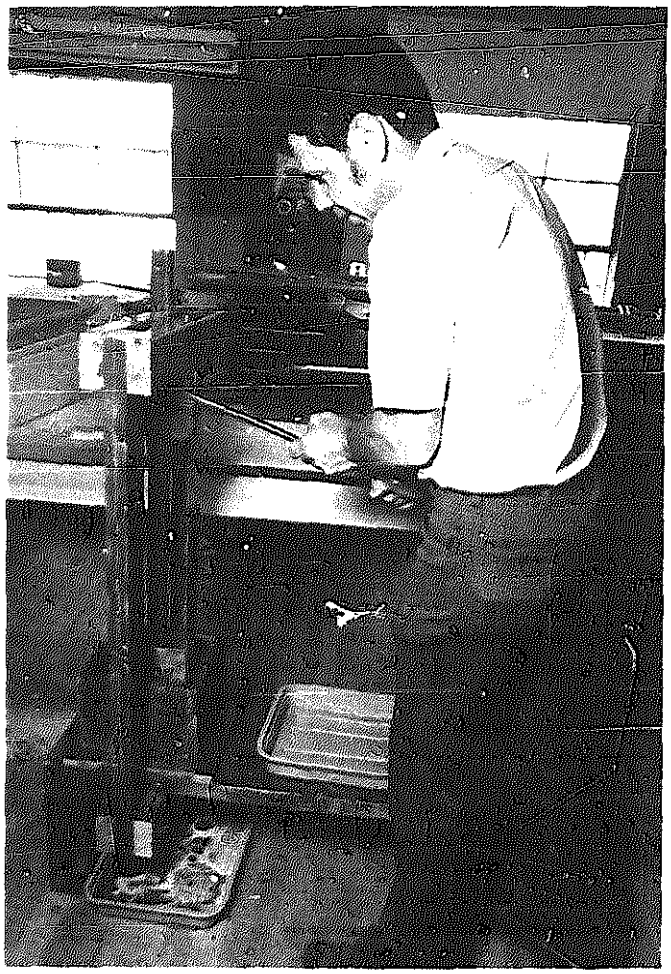
Miscellaneous

1 bumper jack

Construction

1. Cut a 36-inch length of 2 x 12 and four 11-inch lengths of 2 x 4. Using 16d nails and glue, fasten the 2 x 4 legs to the bench.
2. Cut four 19-inch lengths of 2 x 4 for jack support crossmembers. Fasten one to the bottom of the bench, against the front legs. A narrow face of the 2 x 4 should be against the bench bottom, a broad face against the legs. Use glue and 16d nails, driving the nails through the support into the legs, and through the bench into the support. Using a short 2 x 4 as a temporary spacer, locate the second lower support crossmember and glue and nail it in place. Then remove the spacer.
3. Construct the box. The press can have a plywood box, but you can construct yours of 1 x 10 material. Cut four 8-inch by

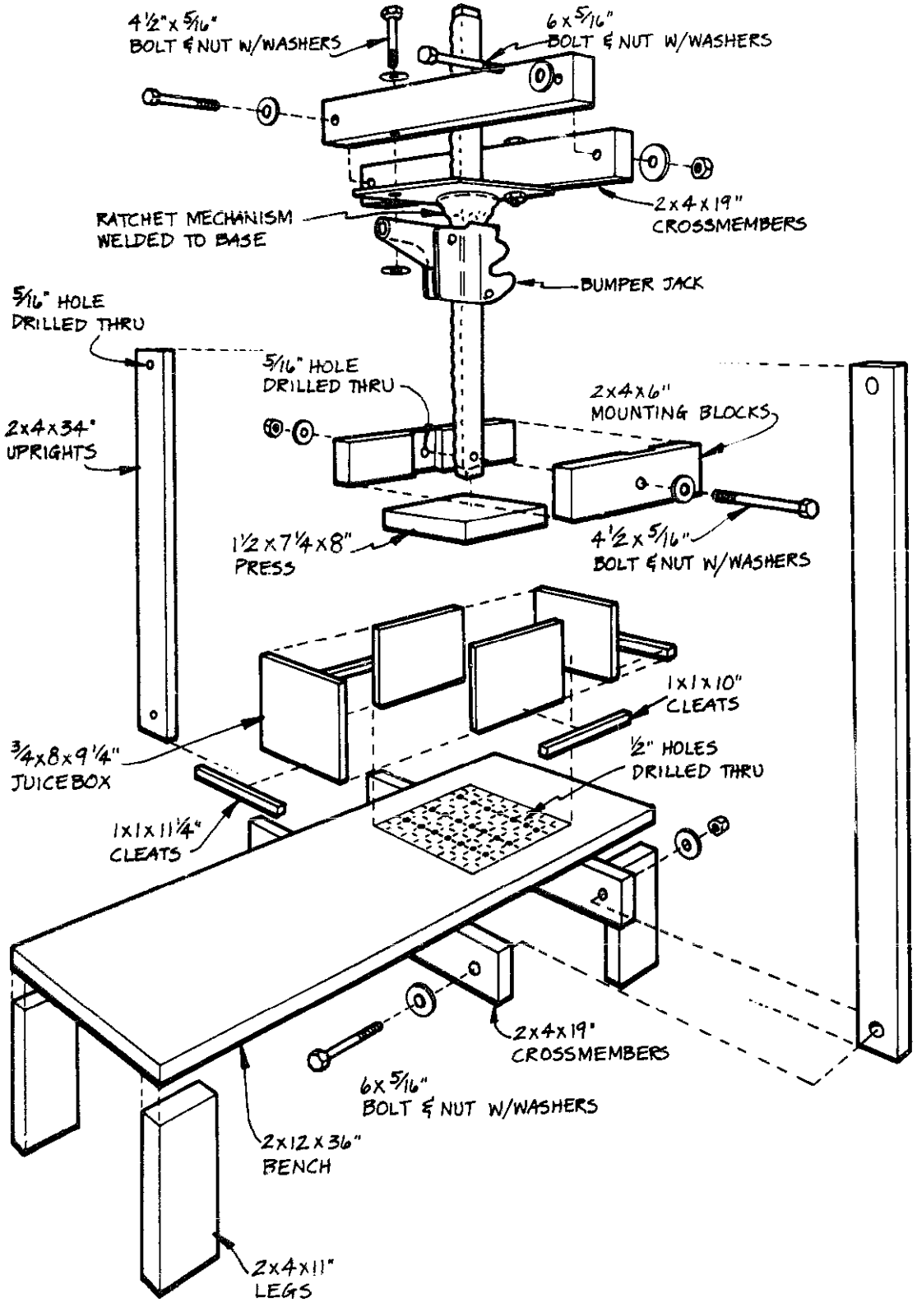
* Reprinted from *Build It Better Yourself*, by the editors of *Organic Gardening and Farming* (Emmaus, Pa. Rodale Press, Inc. 1977).



Bumper Jack Juice Press

9¼-inch pieces of ¾-inch plywood, then glue and nail them together, using 8d nails, forming the juice box.

4. Place the box in position, centered on the bench between the supports. Scribe a line on the benchtop around the inside of the box. Remove the box, then drill three rows of ½-inch holes through the bench. You must locate the rows of holes so they penetrate the bench in front of, between, and behind the supports. The juice will run out of the box through these holes. To speed that process, a crosshatch pattern of grooves should be routered into the bench within the confines of the box. In doing this, be sure not to damage your router bit on the nails you've driven into the bench to secure the jack support crossmembers. Now replace the box and toenail it in place with 6d nails. Cut two 11¼-inch and two 10-inch lengths of 1 x 1 stock and using 6d nails, fasten them to the bench around the outside of the box.
5. Modify the bumper jack. The jack shaft socket in the base must be cut off so the shaft will pass through the base. Then the ratchet mechanism must be welded to the base, so the base moves up and down the shaft with the ratchet mechanism. A welding shop can do this work quickly and inexpensively.
6. Cut two 6-inch lengths of 2 x 4. With a backsaw and chisel, cut a groove across the center of a broad face of each to accommodate half the thickness of the jack shaft. The two blocks are then sandwiched with the end of the shaft between them, as shown. Drill a 5/16-inch hole through the three-piece


4½"x 5/16" BOLT & NUT W/WASHERS
6 x 5/16" BOLT & NUT W/WASHERS
RATCHET MECHANISM WELDED TO BASE
2x4x19" CROSSMEMBERS
BUMPER JACK
5/16" HOLE DRILLED THRU
5/16" HOLE DRILLED THRU
2x4x6" MOUNTING BLOCKS
2x4x34" UPRIGHTS
1½x7¼x8" PRESS
4½x5/16" BOLT & NUT W/WASHERS
1x1x10" CLEATS
½" HOLES DRILLED THRU
¾x8x9¼" JUICEBOX
1x1x11¼" CLEATS
2x4x19" CROSSMEMBERS
6x5/16" BOLT & NUT W/WASHERS
2x12x36" BENCH
2x4x11" LEGS

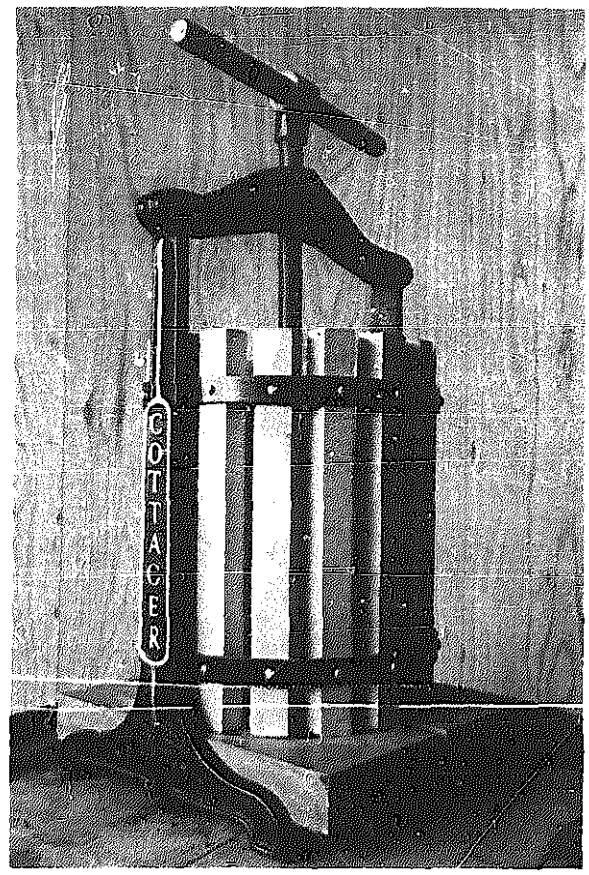
assemblage and fasten it together with a 4½-inch by 5/16-inch bolt. Use fender washers on each side of the assemblage.

7. Cut an 8-inch length of 2 x 12, then rip it to the width of a nominal 2 x 8, that is, an actual 7¼ inches. Nail this piece to the 2 x 4s fastened to the end of the jack shaft, being sure to position the wood grains of the two parts perpendicular to each other. Use 16d nails.
8. Cut two 34-inch lengths of 2 x 4, for the jack support uprights. Slip one between the two crossmembers on each side of the bench, drill a 5/16-inch hole through crossmembers and upright, then bolt them together with a 6-inch by 5/16-inch bolt and nut with fender washers. Set the jack in place, then take the two remaining upper jack support crossmembers (cut at the outset of the project) and, after drilling the appropriate holes, bolt them to the support uprights. Use 6-inch by 5/16-inch bolts and nuts with fender washers.
9. Slide the jack-base/ratchet mechanism up the shaft until it seats firmly against the upper crossmembers. Drill a 5/16-inch hole through the metal base and each crossmember. Then secure the metal jacking mechanism to the crossmembers with 4½-inch by 5/16-inch bolts and nuts, with a fender washer included against the wood surface.
10. Paint the entire press with a high-quality nonleaded enamel paint.

SOURCES OF JUICE PRESSES

The AVI Cottager

The Cottager is a simple, heavily constructed tabletop fruit or wine press. It is designed for squeezing soft fruits, but it is only efficient if the fruit is either sliced or ground beforehand. No grinder is provided. The hardwood tub has beveled staves for easy cleaning, stands 11 inches high and is 9 inches in diameter. The cast-iron frame and oak base produce a maximum in strength and rigidity. The ¾-inch press-screw passes through a heavy cast-iron crossarm and applies pressure to an iron foot attached to a wooden disc that fits inside the tub. The base



AVI Cottager

is 11 inches square, height is 21 inches, and the weight is 30 pounds.

The AVI American Harvester

The American Harvester double-tub cider mill is a hand-operated mill capable of doing both pressing and grinding at the same time. The double-tub feature becomes a practical advantage when you're processing a large number of apples. The quantity of apples processed depends on the speed of the operator(s). Experience has shown that two people can produce as much as 30 gallons in one hour (that's the current record), but ordinarily, two people working at a steady pace should not expect to produce more than 80 gallons of cider in an average day.

The basic frame is constructed entirely of oak, the tray and hopper of maple and alder, respectively. All joints are dadoed (rectangular grooves are cut in them) and cross-bolted for

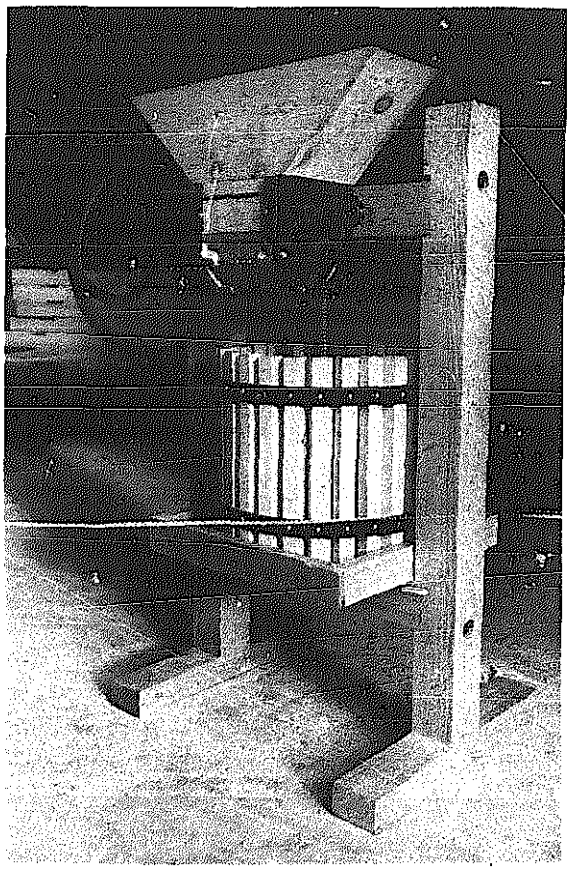


AVI American Harvester

structural rigidity. The hardwood tubs are 12 inches high and 13½ inches in diameter, and have beveled staves for easy cleaning. The press-screw is 1½ inches in diameter; the grinder housing is all cast iron. The grinding cylinder is laminated hardwood with inserted stainless steel teeth. A 16-inch flywheel and 3 to 1 gear ratio accompany the handle. Overall size is 22 inches wide, 36 inches long, and 45 inches high. The press weighs approximately 200 pounds.

The Villager

The Villager is a single-tub cider or wine press with the same basic frame and press-screw assembly as the double-tub model. It has been specifically designed as an all-purpose fruit press which is capable of grinding and squeezing a variety of fruits, including apples. The grinding attachment is mounted directly over the tub, allowing the pulped fruit to be squeezed in place. The large bevel-staved tub holds about a bushel of pulped apples and will yield from 1 to 3 gallons per press (depending on the kind of apples used). The handle is a heavy flywheel with direct drive attached to the grinding shaft. The overall size is 18 by 22 by 42 inches high. Weight is about 125 pounds.



AVI Villager

The above three presses are available from:
American Village Institute
440 Meyers St.
Kettle Falls, WA 99141

Rolling River Presses, Inc.
Dept. 499, 5 Ranch Rite Rd.
Yakima, WA 98901

Berarducci Brothers

Berarducci Brothers are manufacturers, exporters, and importers of Italian specialty equipment for the kitchen. Their product line includes a variety of electric and manual fruit

crushers and both hydraulic and press-screw fruit presses, for example:

Superior Electric—A ¼ h.p.-driven mill for grapes. The roller is of cast aluminum, 9 inches by 4¼ inches. Weight: 100 pounds.

Ontario Electric—A ¼ h.p.-driven mill for apples, pears, and plums. Roller is cast aluminum, 5¾ inches by 17 inches. Weight: 75 pounds.

Erie Electric—A grape crusher with 10 by 3½ inch cast aluminum rollers. It is driven by a ¼ h.p. motor. Weight: 37 pounds.

Michigan—A manual press with all red oak frame and hopper, and double-aluminum rollers; handle-driven for grapes. Weight: 25 pounds.

Erie—A manual press with all-aluminum hopper, sharp teeth-type aluminum single-roller mounted on an aluminum frame, and red oak hardwood cross handles; handle-driven for grapes. Weight: 21 pounds.

Superior—A manual fruit crusher with all red oak wood frame and hopper, double-aluminum rollers, and adjustable bearings for spacing rollers; flywheel-driven for grapes.

The six sizes of hydraulic fruit presses are constructed of selected red oak hardwood to purify and not taint the delicately flavored juices. All cast-iron parts are machine finished for easy operation and painted with a heavy, blue, acid-resisting enamel. The diameter of the pressing plate varies from 16 to 25 inches, according to the size of the model. Its capacity for crushed pulp ranges from 150 to 800 pounds.

One press-screw press is available with a ratchet system handle, 11-inch diameter press plate and ¾-inch diameter press screw. It weighs 30 pounds and has a capacity for 60 pounds of crushed pulp.

Berarducci Brothers Mfg. Company, Inc.
1900 Fifth Ave.
McKeesport, PA 15132

Fruit Press

The Colonial-style grinding unit of this fruit press has stainless steel cutters mounted in a 4-inch wooden roller with a 12-inch diameter flywheel. A bushel of apples can be ground in 15 to 20 minutes. Pressing 3 gallons of cider takes only 3 minutes. The fruit press stands 4 feet high, and is made of hardwoods, spruce, and exterior plywood. Attached to the press, the grinder will drop fruit pulp directly into the pressing tub, or it can be removed and bolted to another support. This way, two people can work together, one grinding and the other pressing. The press plate is driven by a 1-inch diameter, threaded steel press-screw. The unit comes unassembled.

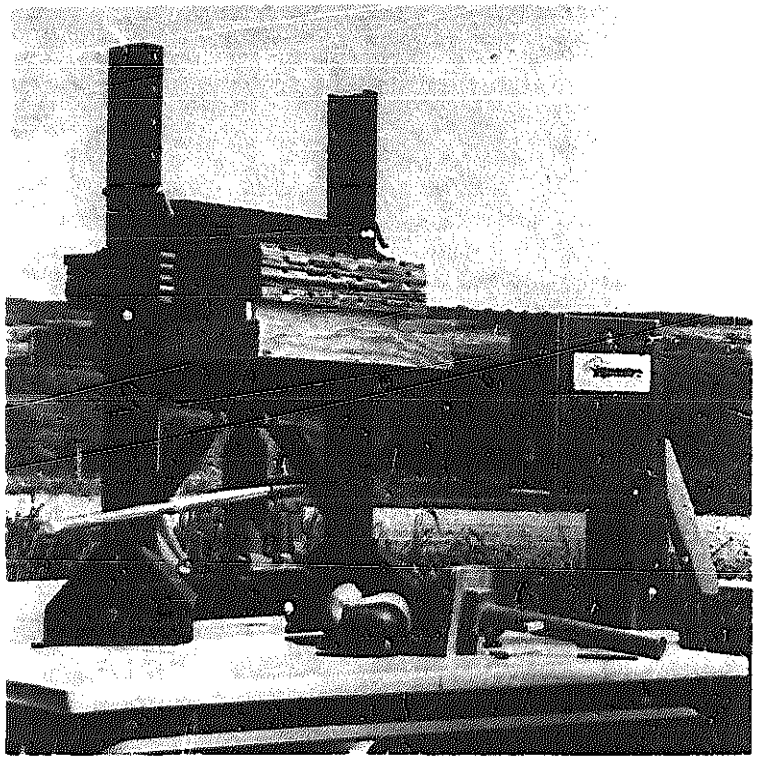
Cumberland General Store
Rt. 3
Crossville, TN 38555

Farnam Sunrise Equipment & Supplies
P.O. Box 12068
Omaha, NE 68112

Garden Way Research
Charlotte, VT 05445

Good Nature Fruit Press

Good Nature Products offers three sizes of hydraulically operated fruit presses. The hydraulic jack employed can apply 6,000 pounds of pressure and will retract itself with one turn of a valve, unlike the old press-screws which had to be cranked backwards before starting a second batch. The familiar slotted tub of other models is replaced in this one with several layers of slotted, flat wooden racks between which cloth bags full of pumice are squeezed. The racks insure that no drop of juice has to force its way through more than one inch of pulp, whereas the old tub presses required that juice travel through as much as 10 inches of packed fruit pulp. This press yields about 3 or 4 gallons of juice from each bushel of apples. The grinder design incorporates a rotating drum with short, stainless steel blades that shave apples gradually as they rotate, forcing the pulp through a narrow slot from which a coarse applesauce emerges. The drum is turned with a hand crank, electric drill, or ¼ h.p. electric motor. Available models



The Goodnatured Fruit Press
Good Nature Products, Inc.

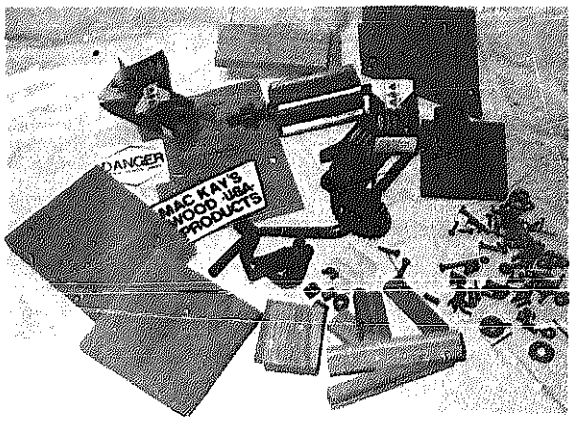
include a 130-pound press with a capacity of 1 to 5 bushels for a maximum output of 60 gallons per hour, a 110-pound press with a capacity of 1 to 2½ bushels for a maximum output of 30 gallons per hour, and a 55-pound table press with a 1-bushel capacity for an output of 12 gallons per hour.

Good Nature's electric grinder is self-feeding, has all stainless steel parts, grinds up to 30 pounds of apples per minute, and is powered by a ½ h.p. electric motor. It can be used to grind or shred any fruits, vegetables, or cheeses. The company's manual grinder is hand crank operated, but may be automated with an electric drill. The polyvinyl chloride drum with stainless steel blades will grind almost any fruit or vegetable.

Good Nature Products, Inc.
4879 Old Buffalo Rd.
Warsaw, NY 14569

Hand Crank Hopper Kit

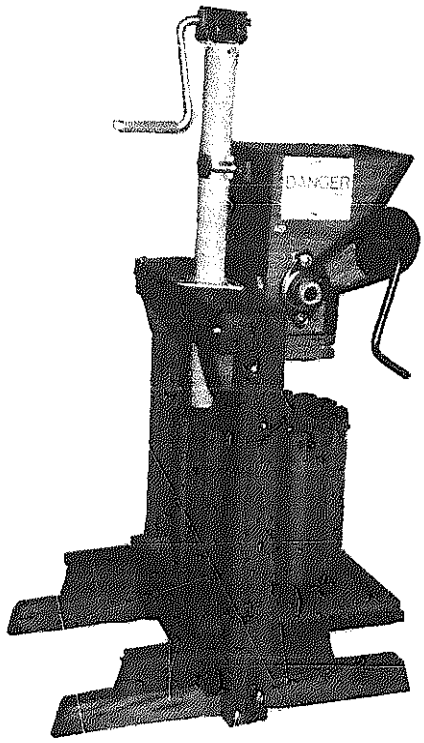
This kit includes a precut oak frame, crushing roller, and all the hardware you need, ready for assembly.



Hand Crank Hopper Kit
MacKay's Wood Products

Portable Hand Crank Press

This press is of the oak stave barrel-type. The grinder is positioned directly over the press tub and is manually operated with a gear reduction crank. The press is hand cranked also. The



MacKay's Portable Hand Crank Press
MacKay's Wood Products

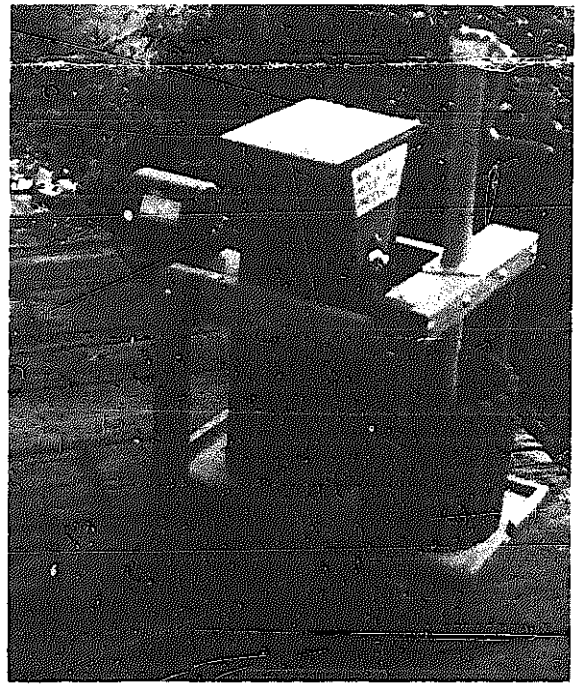
unit is 18 inches wide, 22 inches long, and 35 inches high: Weight: 60 pounds.

Electric Press Models A223 and A203

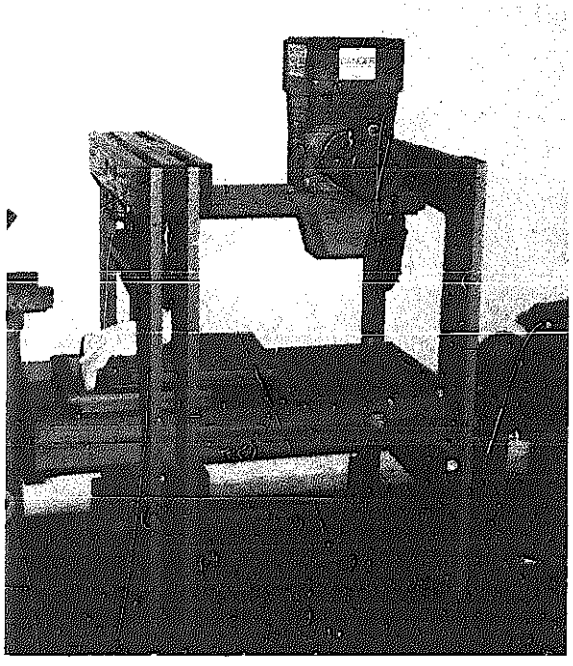
Complete and ready to run, this press is supplied with either one or two oak drums. A ¼ h.p. electric motor drives the grinder. The press is hand cranked. This press is 18 inches wide, 29 inches long, and 30 inches high. Weight: 100 pounds.

Commercial Press

This press replaces the stave press barrel with a 17-inch oak press rack. It has a high-speed, six-knife cutter head in the grinder which is powered by a 1 h.p. electric motor. Thirty-inch, heavyweight, nylon cloths are provided to contain the fruit pulp during pressing. Pressing is done by a 3,000 pound hydraulic jack. Model C1K1 comes with six press cloths, seven oak racks and one oak cheese form. Model C2K2



MacKay's Electric Press
MacKay's Wood Products



MacKay's Commercial Press
MacKay's Wood Products

comes with 12 press cloths, 13 oak racks and one cheese form.

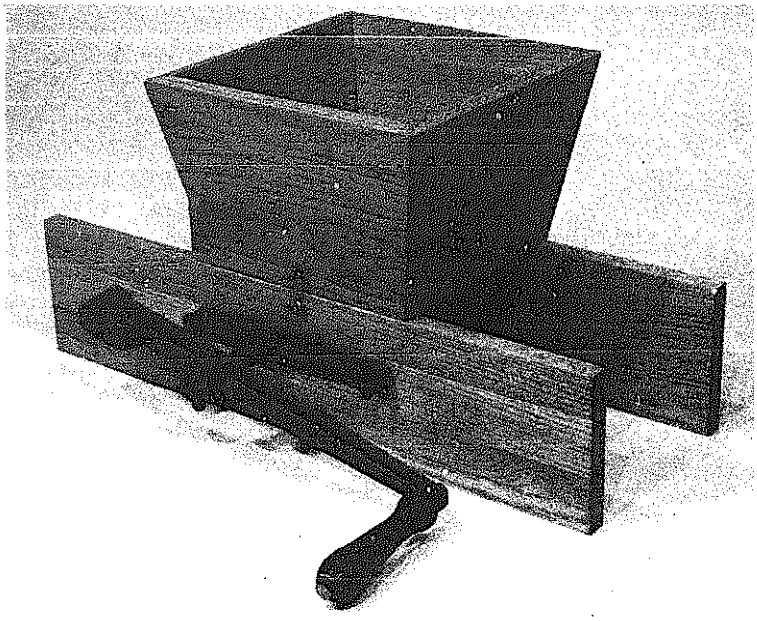
The above four presses are manufactured by:
MacKay's Wood Products
10th and Taylor Ave., P.O. Box 1023
Bellingham, WA 98225

Bell's Hand-Turned Crusher

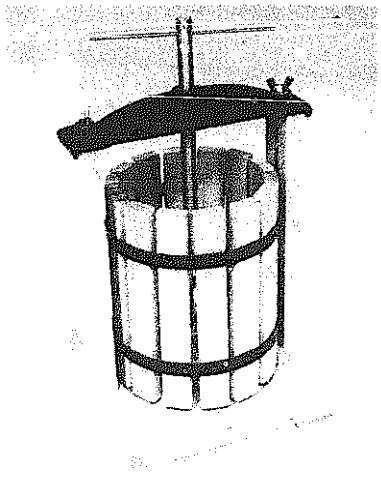
This press has a finished hardwood hopper and sides with cast-iron cutter, side mounting plates, and a counterbalanced crank. A perforated screen allows apples and fruits to be ground to the proper size. The grinder will process approximately 90 pounds of apples per hour. The 24 by 13 by 13-inch grinder is easily disassembled for easy cleaning. Shipping weight: 38 pounds.

Bell's Fruit-Wine Press

This press is constructed of cast iron and white oak (a wood that is favored because it will not impart any undesirable taste to the juices.) It has a vertical-slat press tub and hand-operated press-screw. Shipping weight: 35 pounds.



Bell's Hand-Turned Crusher
C.S. Bell Co.



Bell's Fruit-Wine Press
C.S. Bell Co.

Both presses are manufactured by:
C. S. Bell Co.
170 W. Davis St., Box 291
Tiffin, OH 44883

Sears' Hand-Turned Fruit Crusher

This model comes with cast-iron crusher teeth, steel crusher screen, and oak hopper and sides. It holds one peck of apples and measures 24 by 9½ by 13 inches.

Sears, Roebuck & Co.
Farm and Ranch Catalog

Five-Quart Fruit Press

Of cast-iron and hardwood construction, this press has a capacity of approximately 5 quarts. It has a vertical-slat tub and hand-

operated press-screw. Shipping weight: 24 to 25 pounds.

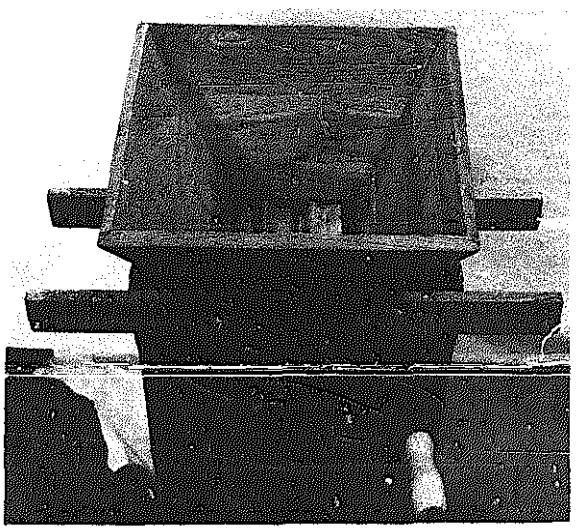
Belknap, Inc. (distributor)
P.O. Box 28
Louisville, KY 40201

Glen-Bel's Country Store
Rt. 5, Box 390
Crossville, TN 38555

Sears, Roebuck & Co.
Farm and Ranch Catalog

Cumberland's Fruit Crusher

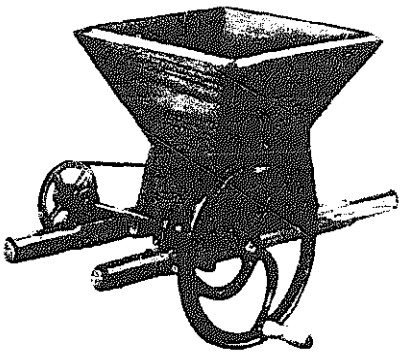
For grapes, berries, cherries, and other soft fruits, excluding apples, this crusher has an oak frame and an 18½ by 18-inch hopper which holds 30 pounds of whole grapes. Its two stationary rollers are made of aluminum. Shipping weight: 25 pounds.



Fruit Crusher
Cumberland General Store

Apple Crusher

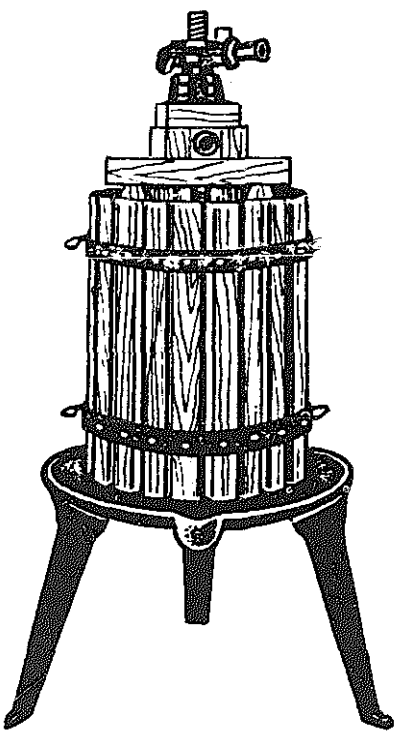
The machined claw-cut teeth on this press work well to extract juice from all kinds of fruit, especially apples, which are difficult to grind. A selected hardwood 18½ by 17-inch wide hopper with a 45-pound capacity feeds a 32 by 16½-inch cast aluminum roller. The handle operates on a 17-inch diameter flywheel.



Apple Crusher
Cumberland General Store

Cider Press

Constructed of red oak for purer juice and for strength, this press weighs approximately 90 pounds and can hold 250 pounds of crushed apples. Its cast-iron parts are machine finished and painted with acid-resisting enamel. The press stands 43 inches high, and tub size is 12 by 18 inches.



Cider Press
Cumberland General Store

Kits

Cumberland also carries a fruit grinder kit and a cider press kit. Both kits contain plans, and all the hardware necessary for building. No lumber is included.

The above four presses are available from:
Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

Day Equipment

Both electric and hand-operated presses are available from this company for use in roadside stands and small orchards. Graders, press racks, cloths, labels, filters, pasteurizers, picking bags, cutters, and all the accessories needed for a small operation are also available.

Day Equipment Corp.
1402 E. Monroe
Goshen, IN 46526

Hydraulic Cider Presses, Palmer-Style

These presses are specially suited to roadside stand and orchard use. A full line of accessories is available.

Orchard Equipment & Supply Co.
Conway, MA 01341

Wine, Fruit, and Cider Press Plans

Plans for a wooden-framed, slat-sided, oak, basket-style press with a hand-cranked press-screw are included in a catalog from New Jersey. An electric drill and router are required to build the press, but no other special tools are needed. Instruction plans only are provided.

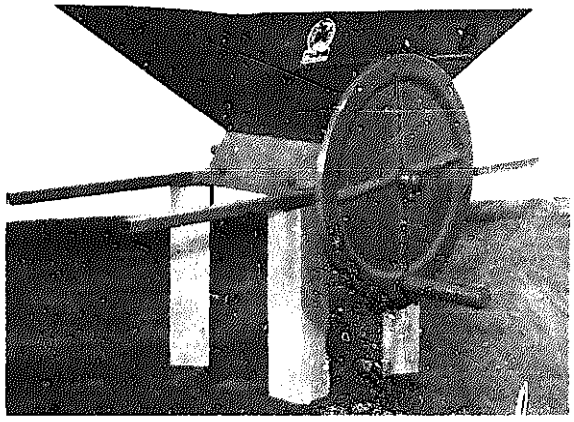
Dorsay Poor Man's Catalog 3
240 Kinderkamaca Rd.
Oradell, NJ 07649

Mearelli Presses

Mearelli offers a full line of hand-operated and electric fruit crushers, hydraulic, vertical-staved presses, and hammer mill-type electric crushers. Units range in size from models appropriate for the home and small farm to large commercial applications, with a full range of sizes in between. Mearelli also offers accessories for all your wine-making needs, including wood kegs, wine pumps, and bottle corkers.

Manual Fruit Crusher

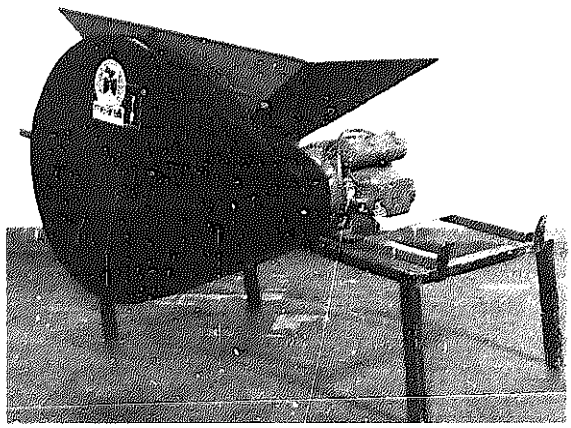
This manual crusher, available in either wood or iron, has roller supports and gears enclosed in cast iron. Five sizes are available in iron, ranging in weight from 28 to 45 pounds. Three sizes are available in wood, ranging from 30 to 39 pounds.



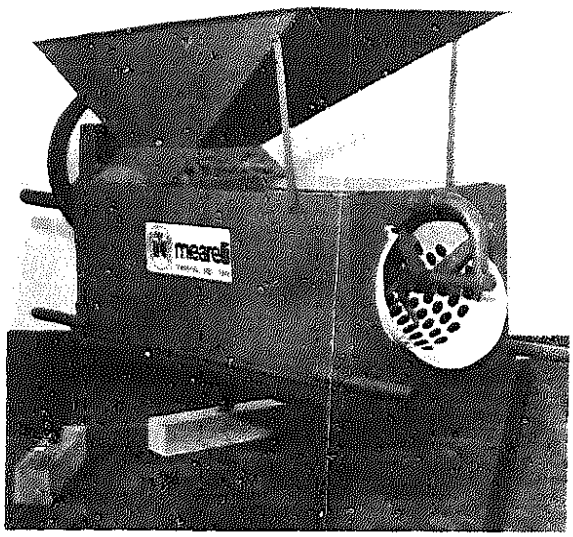
Iron Manual Crusher
Mearelli S.P.A.

Motored Crusher

Two models of this powered crusher are available, with either monophase 0.5 h.p. motor weighing 56 kilograms, or three-phase 0.5 h.p. motor weighing 59 kilograms.



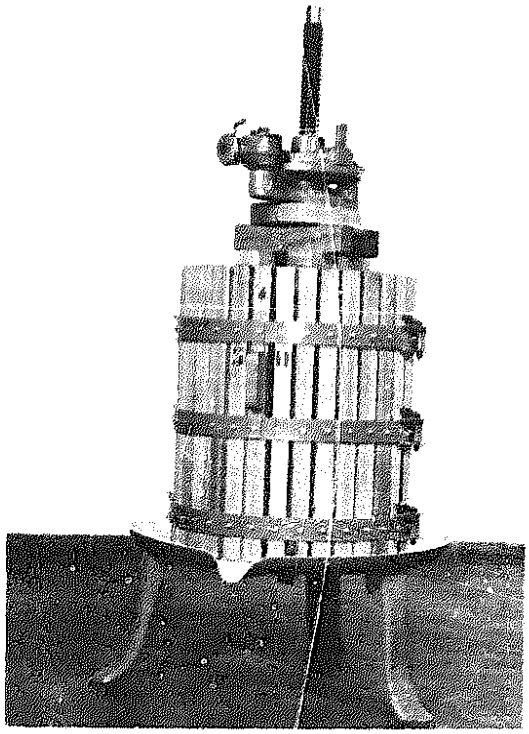
AM Motored Crusher
Mearelli S.P.A.



PVD/15 Manually Operated Stemmer-Crusher
Mearelli S.P.A.

PVD/15

This model is a manually operated stemmer-crusher, with a removable screen for maintenance. Weight: 60 kilograms.



Lever Press
Mearelli S.P.A.

Lever Press

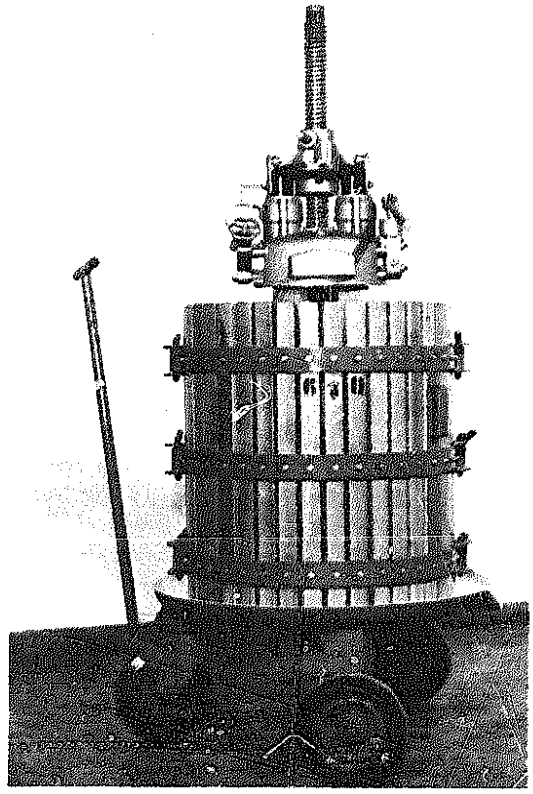
This lever press comes in fourteen sizes ranging in weight from 17 to 750 kilograms.

Hydraulic Press on Wheels

Utilizing a hydraulic jack, this press operates with glycerine oil and attains pressures of 350 to 400 atmospheres. Eight models are available, ranging in weight from 160 to 830 kilograms.

At this time, Mearelli is interested in locating distributors for its products in North America.

Mearelli S.P.A.
Trestina (pg)
Italy



Hydraulic Press on Wheels
Mearelli S.P.A.

CORN SHELLERS

Feed mills grind cobs and kernels together for cattle feed, but hand- or power-operated

shellers are required to separate the kernels from the cobs before the corn can be ground into meal for people and for most other animals.

Several manufacturers produce small, hand-operated shellers which can be clamped onto a board or the edge of a box or barrel. Larger shellers are turned by a handle, by pedals, or by belt drive from an engine or electric motor as required. Large power-driven maize shellers are often fitted with cleaning fans and screens to separate the grain from husks, dust, and spent cobs.

Hand Corn Sheller

Appropriate for shelling small amounts of a wide variety of corn, this hand sheller is especially desirable for shelling seed corn because it does not break off the germ ends of the kernels. It is similar to the sheller described in the following article.

Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

Nasco Agricultural Sciences
901 Janesville Ave.
Fort Atkinson, WI 53538

A MAIZE SHELLER FOR EVERY HOUSEHOLD*

by Dr. D. J. Hilton

Senior Lecturer, Dept. of Mechanical Engineering, University of Nairobi, Kenya

One type of hand sheller currently sold in parts of Africa is made from a metal tube, with internal ribs set in the direction of the cylinder axis. The sheller is held in one hand while the other hand pushes the maize cob into the tube with a twisting action. The internal ribs strip the kernels from the cobs, and the kernels fall out the bottom of the tube. This sheller, which is now being made from an aluminum casting, has been found to have two disadvantages. First, the ribs are too numerous and tend to become clogged with grain. Second, the sheller is really only suited to one diameter of cob. Where both traditional and hybrid varieties are grown, therefore, it is not capable of stripping all cobs satisfactorily.

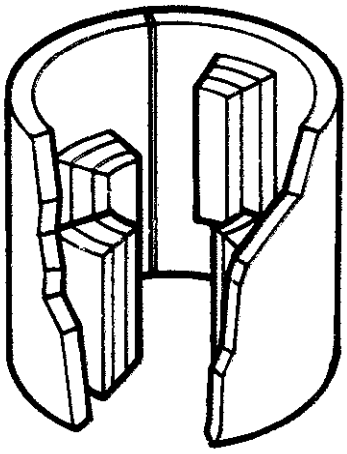
I have overcome these difficulties by redesigning the tube sheller and incorporating two novel features. At the same time, the cost has been lowered by a change of material.

The tube of the new sheller is constructed from a short length of 2-inch diameter rigid, polyvinyl chloride water pipe. This is a readily available material in industrial centers in most countries. The ribs are made from the same pipe, cut into thin strips, and glued together in stacks of three or four. For glue, a polyvinyl chloride solvent is used which is supplied for use with polyvinyl chloride water pipe by all distributors. Four such ribs are then glued to the inside of the tube at 90-degree intervals. This placement allows the ribs to reach the core of the maize cob, and still leaves enough space between them to allow the grain to drop through. The two novel features I introduced are as follows:

1. A slit is made along the tube to allow it to expand when very large cobs are being stripped. This is made possible by the elasticity of the material. Residual stresses in the material, as a result of the pipe extrusion process, ensure that the tube normally remains well closed.
2. One of the four internal ribs is positioned higher up the tube than the other three and this is the rib which does most of the stripping. It is found that this feature results in an easier stripping action than when four ribs strip off the grain simultaneously.

The performance of the new maize sheller is quite impressive and a dry cob can be stripped in about 5 to 7 seconds. This compares very favorably with the performance of other designs, though

* Reprinted with permission from *Appropriate Technology*, August 1976.



A cutaway view of a PVC sheller with a slit in one side for expanding with the size of the cob.

it is accepted that the vigorous wrist action involved could not be maintained for prolonged periods. The tools required for manufacturing this sheller are minimal; they consist of a hacksaw, small clamp or vice, and sandpaper. The cement used is a standard polyvinyl chloride solvent which produces a very powerful bond, provided the surfaces are free of grease.

The material cost including normal waste is low, and each sheller takes around 1 to 1½ hours to assemble by hand. The product is beginning to sell in a few areas on a trial basis and indications are that demand will be considerable when the product is given a little promotion.

A SIMPLE MANUAL MAIZE-SHELLING DEVICE*

by Professor A. S. Rana

Head of the Department of Agricultural Engineering
and Land Planning, University of Dar-es-Salaam

In many developing countries, most of the maize (corn) is produced by small subsistence farmers, and whatever little surplus is available is sold at the market. The subsistence farmers in many countries in Africa grow only a few hectares of maize, and these are often intercropped. The yields in general are low, about 1,000 kilograms per hectare. Under these conditions all the shelling is done by hand, and the following methods are generally used:

1. With bare hands, holding the cob in the palm with four fingers, a person removes the grains one by one with the movement of the thumb. The shelled corn is consumed or sold as is without cleaning or grading.
2. Rubbing a shelled cob on a cob to be shelled is faster than the first method but is more tiring and requires skill and practice. It is not very suitable for maize with a high moisture content, as the grains are sometimes bruised and the shelling rate is low. The shelled grains are used as in the first method.
3. This method involves putting the husked cobs in a bag and beating them with a stick while turning the bag. Later on, the cobs and grains are taken out of the bag and cobs are picked. Any grains remaining on the cobs are taken off by hand as in the first method.
4. There are some variations of this method, but basically, the cobs are spread on a raised platform made of sticks and bamboo poles, with small gaps between the adjoining pieces. The spread cobs are beaten with a stick; the shelled grains fall through the gaps; the remaining grains on the cob are removed by hand.

* Abridged from *Appropriate Technology*, vol. 2, no. 1, May 1975.

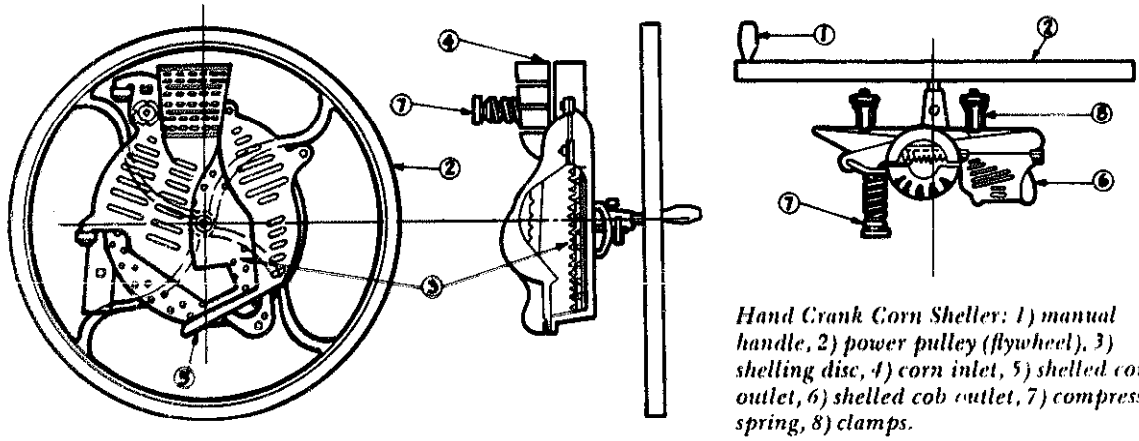
Maize shelling is not a labor bottleneck for the small producer, especially if he is only growing for home consumption. The family sits together in the evening and shells maize by hand, while talking for a few hours. One evening of shelling is sufficient for a week's supply of corn. Most of the maize being brought to the market by the peasant farmer is shelled by one of the four methods described above.

For larger producers, such as those who grow corn to feed their livestock as well as themselves, these simple shelling methods aren't sufficient. The following device has been found to be, on the average, about three times more efficient than the methods described above.

The shelling section consists of U-nails (also called staples) arranged on a wooden board in a way that will facilitate the smooth rubbing of the maize to be shelled. Various arrangements of fixing the U-nails on the wooden board were tried. The best results have been obtained by fixing the U-nails in two rows parallel to each other 1.9 to 2.0 centimeters apart, and 2.5 centimeters between the nails within the row.

HAND-CRANKED CORN SHELLER

A manual cranking handle, sometimes accompanied by a flywheel, powers this simple but effective corn sheller. A compression spring adjustment enables the sheller to adapt to the size of each cob as it enters the feed opening. Husked corncobs are forced by hand into a feeding device which delivers the cob between one stationary and one rotating, toothed, cast-iron shelling plate, and are held in place by spring-loaded stripping claws. The action of the rotating plates causes the cob to rotate in a spiral fashion against the teeth, with the kernels flying off as it feeds through. After shelling is completed, the bare cob follows an ejection path automatically and makes way for the next cob to follow directly, as soon as the operator can feed it into the opening. The least expensive models clamp directly to a fence or tub side while the sturdier, generally faster models come inside a wooden or metal housing. Many come with an attachment for shelling walnuts.



Hand Crank Corn Sheller: 1) manual handle, 2) power pulley (flywheel), 3) shelling disc, 4) corn inlet, 5) shelled corn outlet, 6) shelled cob outlet, 7) compression spring, 8) clamps.

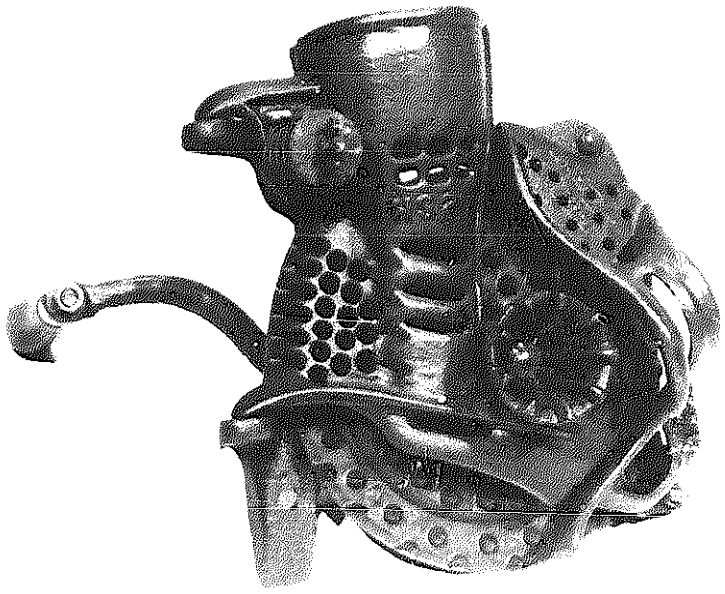
NORTH AMERICAN SOURCES OF CLAMP-TYPE CORN SHELLERS

C. S. Bell Co.
P.O. Box 291
Tiffin, OH 44883

Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204



Cumberland's Red Chief with unshelled corn entering at the top and shelled corn exiting at the bottom.
Cumberland General Store



The ribbed cone in the middle of the C.S. Bell Corn Sheller is an attachment for shelling walnuts.
C.S. Bell

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

Glen Bel's Country Store
Rt. 5, Box 390
Crossville, TN 38555

INTERNATIONAL SOURCES OF CLAMP-TYPE CORN SHELLERS

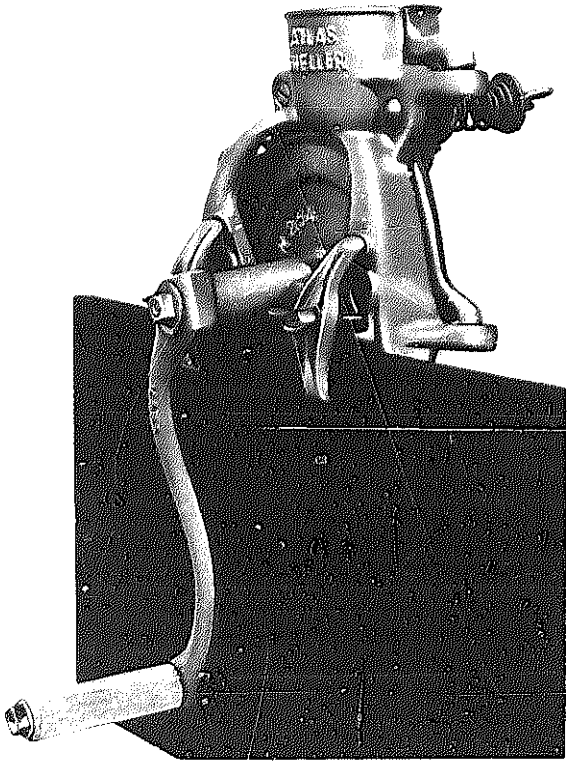
Allied Trading Company (India)
Railway Road, Ambala City 134 002
Haryana, India

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

Dandekar Brothers
(Engineers & Founders)
Sangli, Maharashtra, India

R. Hunt & Co., Ltd.
Atlas Works, Earls Colne
Colchester, Essex CO6 2EP, U.K.



The Atlas Sheller secured to a vertical board as one might attach it to a fence.
R. Hunt

Ernest H. Johnson (Pty.) Ltd.
Box 7536
Johannesburg 2000, South Africa

Ransomes, Sims, & Jeffries, Ltd.
Nacton Rd.
Ipswich, IP3 9QG, U.K.

SOURCES OF OTHER MANUAL CORN SHELLERS

AVI Corn Sheller

This sheller has all-metal parts of either cast iron or steel. The housing frame is constructed of oak, and the remainder of the sheller is alder or maple. The flywheel is 21 inches in diameter and is mounted on a ¾-inch steel shaft. The sheller's dimensions are 12 by 30 by 42 inches, and it weighs approximately 125 pounds.

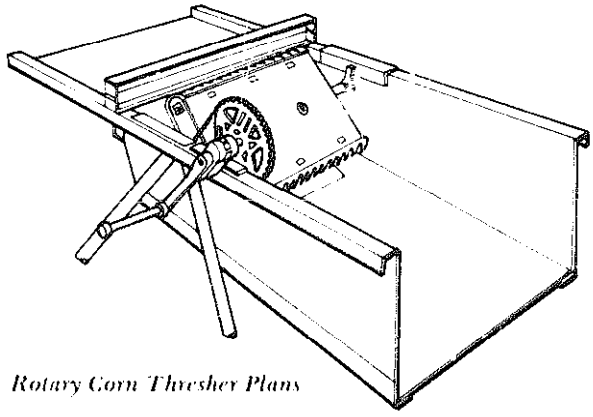


The AVI Cornsheller, showing the hand crank and corn exit. On the other side of the sheller, a large flywheel gives each stroke momentum.

American Village Institute
440 Meyers St.
Kettle Falls, WA 99141

Rotary Corn Thresher Plans

Fully illustrated instructions for building a corn thresher are available from ITDG. On this model, drive is supplied by converting a bicycle pedal and sprocket system into a hand crank.



Rotary Corn Thresher Plans

Intermediate Technology Publications, Ltd.*
9 King St.
London WC 2E 8HN, England

CeCoCo Sheller Type Number 4

Sheller No. 4 is treadle-operated and attached to a stand with driving gears, flywheel, and pedal. The body is made of cast iron, the stand of angle iron. Its capacity ranges between 300 and 350 bushels per hour at a standard rate of 250 revolutions per minute. Shipping weight: 75 kilograms.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

NORTH AMERICAN SOURCES OF POWER CORN SHELLERS

Burrows Corn Sheller

Burrows' Model 22 is the smallest of three available shellers with aspirator and cob blower. Operable with either a 10 or 15 h.p. motor, it will yield a capacity of up to 400 bushels per

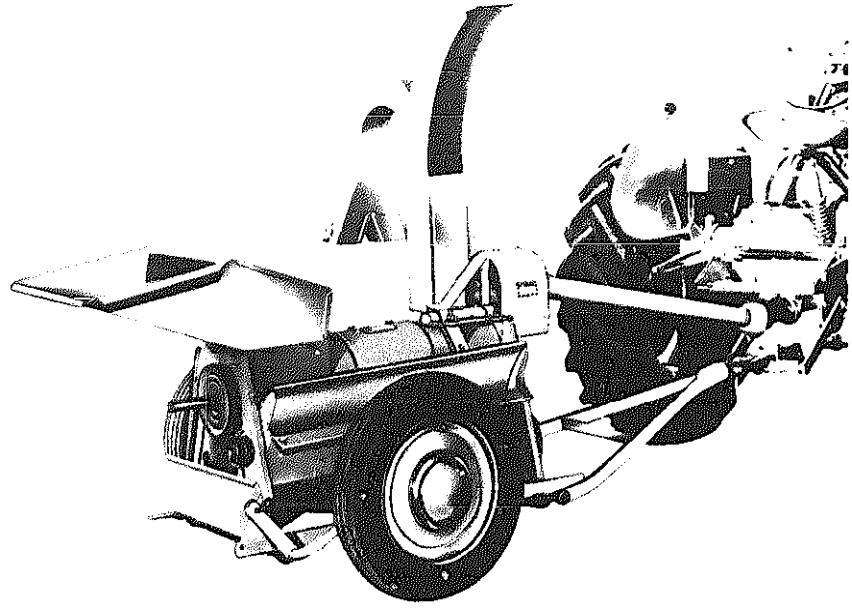
* Intermediate Technology publications can be ordered from International Scholarly Book Service, Inc., Box 555, Forest Grove, Oregon 97116.

hour. The 8-inch diameter cob pipe can be up to 100 feet long with up to 45 feet of vertical pipe left. Height of the sheller is 4 feet. Models are also available to be run with 25, 30, 40, and 50 h.p. motors.

Burrows Equipment Co.
1316 Sherman Ave.
Evanston, IL 60204

Haban Number 101-007 Husker-Sheller

The Haban No. 101-007 Husker-Sheller is made to shell corn of any variety or size. Corn is fed into the machine at a comfortable height of 32 inches. A corn thrower is used to elevate the shelled corn into a truck or storage container. This model is available on wheels or as a stationary unit with a power take-off drive. It requires a 15 to 25 h.p. gasoline or 5 to 7 h.p. electric motor.



Haban No. 101-007 Husker Sheller, complete with two wheel trailer.
Haban Mfg. Co.

SHELLING CAPACITY IN BUSHELS PER HOUR

Condition of Corn	Moisture Content of Corn (Percent)		
	17 Percent and Less	17 to 25 Percent	25 Percent and Greater
Clean corn (no husks)	350 to 500	250 to 350	200 to 250
Corn with 50 percent husks	250 to 350	200 to 250	150 to 200
Corn with 100 percent husks	200 to 250	150 to 200	100 to 150

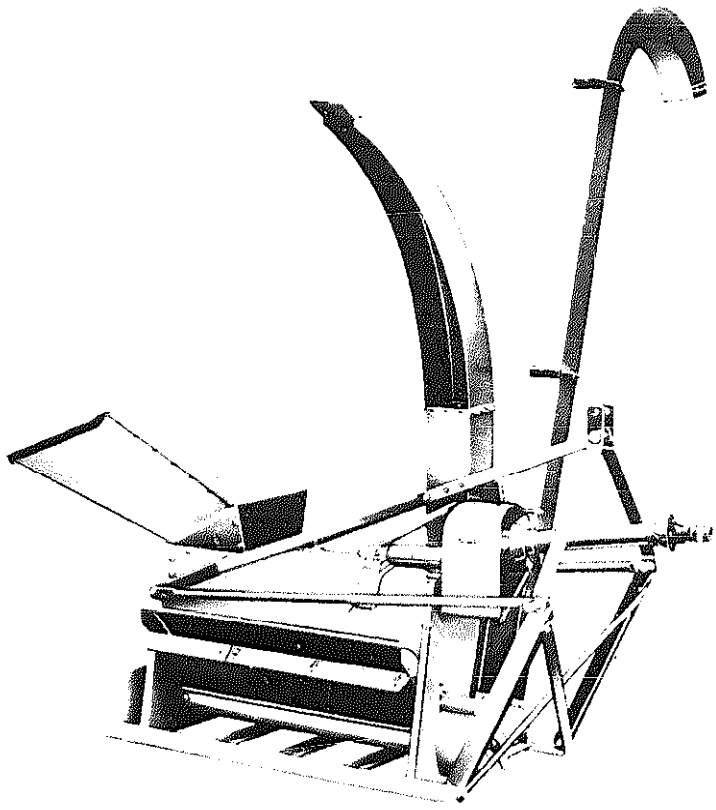
Haban Husker-Sheller

Haban's smaller unit, powered by a 6 h.p. gasoline or 2 h.p. electric motor, also handles all types and sizes of corn. It separates husks, cobs, dirt, and dust. Feeding height is 33 inches.

Both shellers are made by:
Haban Mfg. Co.
Racine, WI 53404

Sears Husker-Shellers

Until 1978, Sears offered a three-point hitch



Haban No. 101-005 Husker Sheller, complete with 3-point lift.
Haban Mfg. Co.

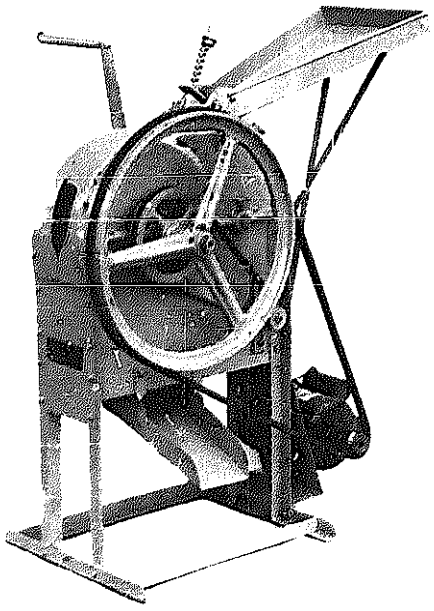
and pull-behind husker–sheller operated off a tractor's power take-off shaft. It could strip husks, extract cobs, and separate and clean shells of most types of corn. The sheller was constructed of 36 by 27 by 56-inch-high, heavy-duty galvanized steel units with low, four-way adjustable hoppers for convenient loading. The cob stacker pipe discharged husks and cobs at many positions. A large cleaning fan and sieve with controlled air blasts cleaned shelled corn three times. Sears discontinued its sheller for lack of demand, but they may return it to the market if a demand reveals itself!

Sears, Roebuck & Co.
Farm and Ranch Catalog

INTERNATIONAL SOURCES OF POWER CORN SHELLERS

Cossul Hand and Power Maize Sheller

This one-hole, spring-type sheller can be operated by hand, yielding 100 to 200 kilograms per hour, or by a 1 h.p. motor supplied with a belt pulley, yielding 200 to 300 kilograms per



Cossul Hand and Power Maize Sheller
Cossul & Co.

hour. The unit is of all-steel construction, weighs 94 grams, and has a built-in cleaning fan.

Cossul & Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

CeCoCo Corn Sheller Type Number 2

Operated by hand, this sheller yields 100 to 150 kilograms per hour; with a ½ h.p. motor, it puts out 250 to 300 kilograms per hour. This machine has a flywheel and can be attached to any box or barrel. It measures 24 by 10 by 7 inches.

CeCoCo Corn Sheller Type Number 3

This sheller has a 2 h.p. motor and yields 750 to 1,125 kilograms per hour.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka, Pref. 567, Japan

Allied Power Maize Sheller

This sheller has a winnowing fan which separates the corn kernels without breaking them. A 5 h.p. motor is required to run the machine.

Allied Trading Co.
Railway Rd., Ambala City 134 002
Haryana, India

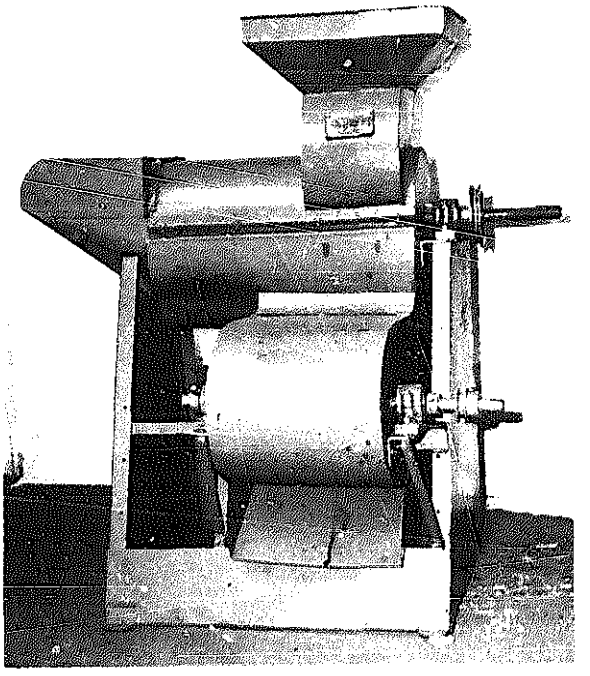
Dandekar Power Maize Sheller

This company offers a 5 h.p. machine which shells up to 1,500 kilograms of corn per hour, and separates the dust and chaff from the grain.

Dandekar Brothers
Sangli
Maharashtra, India

Unitrac Maize Sheller

The Unitrac shells corn by a rolling action at a speed of 600 rpm. It has a shelling capacity of about 2 tons of grain per hour with a 10 h.p. motor.



Dandekar Power Maize Sheller
Dandekar Brothers

Union Tractor Workshop
8B Phase II, Mayapuri Industrial Area
New Delhi, 110 027 India

Laredo Corn Shellers

Laredo's Model MDL-900 is a powerful sheller which produces 3,600 to 6,000 kilograms of shelled corn per hour. It can be operated by a 15 h.p. electric engine or an 18 h.p. diesel/gasoline engine.

Model MDL-500 is attached to a tractor three-point hitch and powered either by the power take-off shaft or by a stationary engine. It will generate 3,000 to 3,600 kilograms per hour with a 5 to 7.5 h.p. electric motor or with an 8 to 10 h.p. gasoline/diesel engine.

Laredo Models S.A. Industria E. Comercio
Rua 1 de Agosto M-67
17.100—Bara(SP) Brazil

Power Maize Sheller

This sheller has an output of 100 kilograms

per hour when driven by a 1 h.p. motor or engine. Shelling gaps are adjustable.

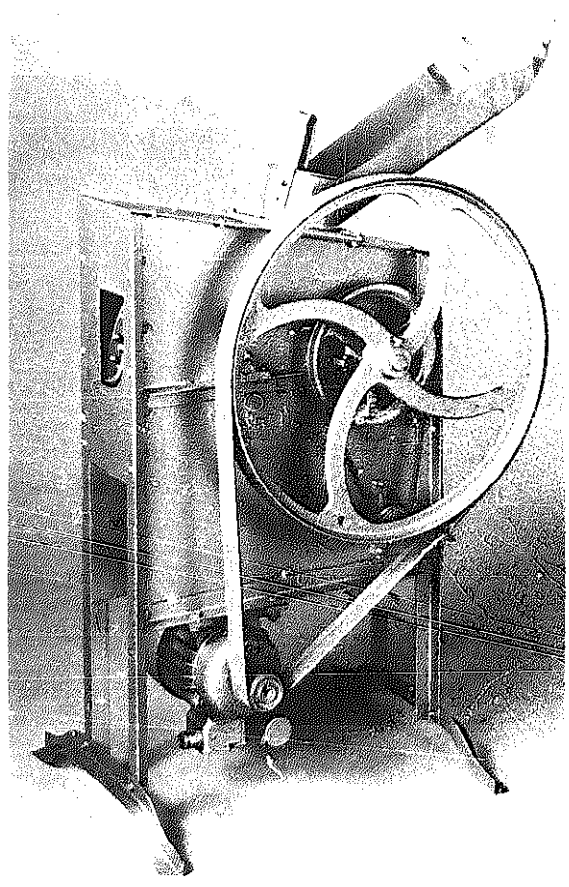
Rajasthan State Agro Industries Corp. Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006, Rajasthan, India

Ransomes Power Maize Sheller

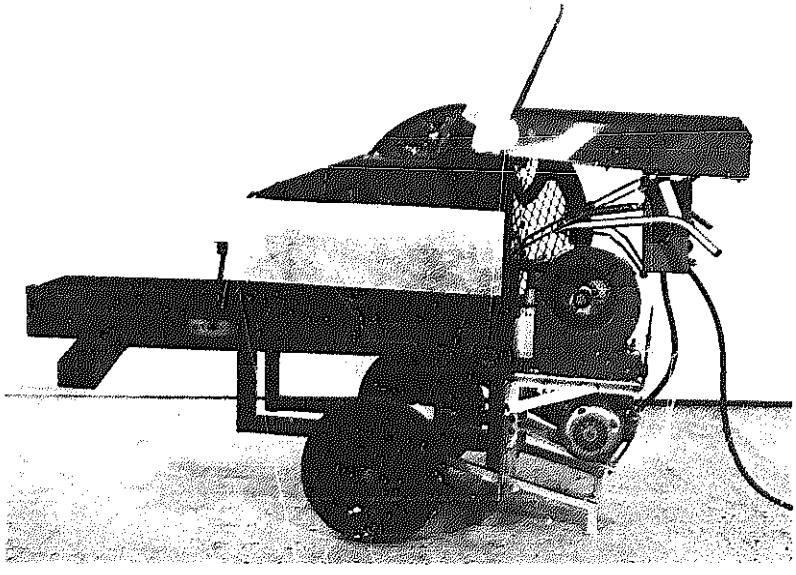
This is an all-steel-construction sheller with a belt-driven winnowing fan. When driven by a ½ h.p. motor, it has an output of 300 kilograms per hour.

The Ransomes 4A

The Ransomes 4A is manufactured for small farmers in developing countries. Husked ears of corn are shelled individually on both sides of a rotating, toothed, shelling plate as the cobs are forced past the plate by rotating, feeding drums. Spring-loaded stripping claws hold the ears against the shelling plate while shelling takes place. The spring tension and the size of the opening are adjustable. Below the shelling mechanism is a cleaning shoe where corn is cleaned and graded. Three screens are provided for the sheller: a 19-millimeter round-hole upper sieve, a 10-millimeter grading sieve, and a 5-millimeter lower sieve to remove chaff. The cleaning shoe is oscillated by a crank pin.



Ransomes Power Maize Sheller
Ransomes, Sims and Jefferies, Ltd.



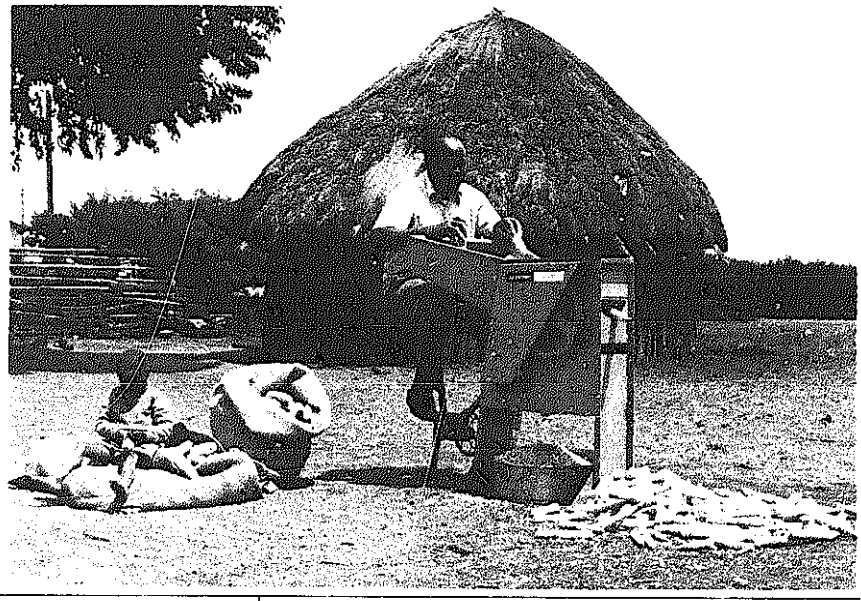
Ransomes 4A Sheller, modified for experimental work.
Agriculture Canada

Moon Sheller

This unit consists basically of a shelling cylinder fitted with renewable pegs. A powerful fan at the bagging point removes flakes, silks, and dust from the corn. This sheller can strip 2,700 to 4,500 kilograms of kernels an hour from husked cobs. It requires 4 to 6 h.p. to maintain a speed of 6,000 rpm. Weight: 200 kilograms.

Cobmaster Sheller

Specially designed for the smaller farmer, the Cobmaster sheller is available with a choice of hand, pedal, or motor drive. Husked cobs are hand-fed from a hopper into two feed holes with adjustable rubbing pads. The internal cleaning fan gives a flywheel effect and will blow light refuse out the front of the machine. The crop falls through the bottom of the machine. Maximum output with a ½ h.p. motor is 750 to 900 kilograms per hour (1,600 to 2,000 pounds).



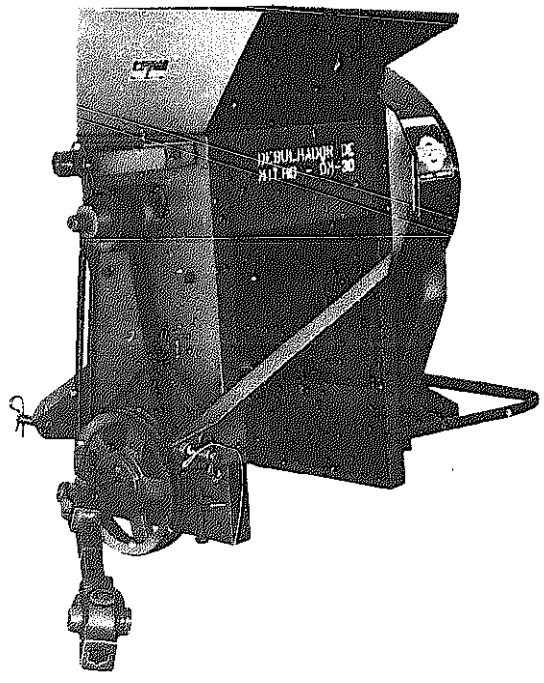
The Cobmaster Sheller
Ransomes, Sims and Jefferies, Ltd.

The above four shellers are manufactured by:
Ransomes, Sims, & Jefferies, Ltd.
Nacton Works
Ipswich IP3 9QG U.K.

Jumil DM-30

For a production capacity of 30 sacks per hour, this corn sheller-thresher can be operated either as a stationary unit or attached to a tractor power take-off and hydraulic lift system. Shelled corn is obtained without crushing the kernels.

Jumil
Justino de Moraes, Iramos S.A.
Batatais, S.P. Brazil



Jumil DM-30
Jumil

SILAGE CUTTERS AND CHOPPERS

CHOPPING SILAGE BY HAND

One way of providing succulent animal feed throughout the year is to cut or chop grass, hay, straw, root crops, or forage crops into small pieces and convert the material into silage. Stored in a silo, anaerobic acid fermentation converts green fodder into succulent feed, a form in which it can be stored through the year.

For small acreages where only one or two animals are to be fed, a simple method of hand chopping can be used to prepare green fodder for storage. All you need are a butcher's knife and chopping block. Hold a bundle of material in one hand and chop against the block with the other. Output and efficiency of this method is low, of course, and the work is tedious. Some foreign companies have devised hand-operated equipment to make the job easier.

A typical hand-operated silage cutter consists of a feed trough with or without conveyor rollers. At the end of the trough, straw is gripped between two toothed rollers which feed it over a shear plate. A pair of rotating knives mounted on a hand-cranked flywheel chops the feed into short lengths. Two men are required for the operation—one to turn the flywheel and the other to feed the machine.

For this cutting tool to function efficiently, it is important that the knives be kept well sharpened, and a few spare sets of knives should be available for regular changing. Even more important, you must keep the correct bevel on the cutting edge (instructions should be provided by the manufacturer). Finally, the knives should be adjusted so that they lightly touch the mouth of the machine over its full width.

SOURCES OF HAND-OPERATED SILAGE CHOPPERS

Dandekar Hand-Operated Chaff Cutter

This implement cuts chaff into 1-inch (25 millimeter) segments.

Dandekar Brothers
Sangli
Maharashtra, India

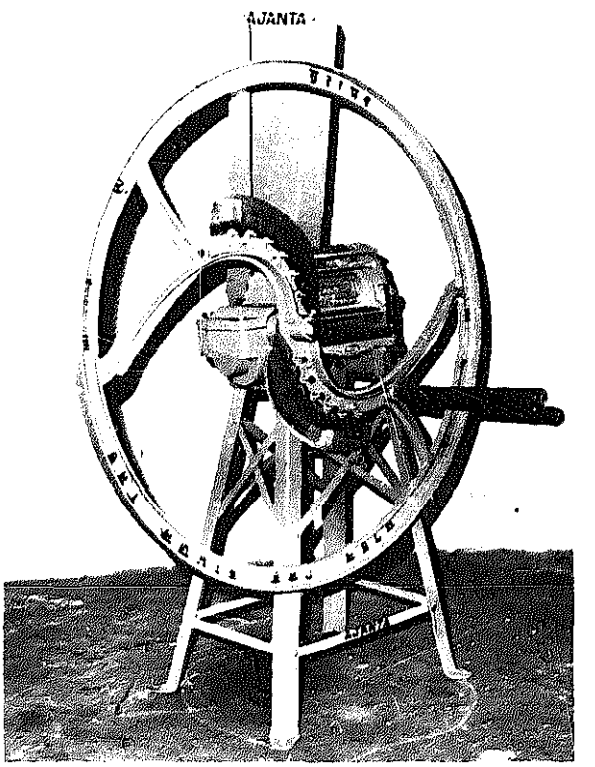
Silex Chaff Cutter

This machine also cuts chaff into 1-inch (25 millimeter) segments.

Ernest H. Johnson (Pty.) Ltd.
Box 7536
Johannesburg 2000, South Africa

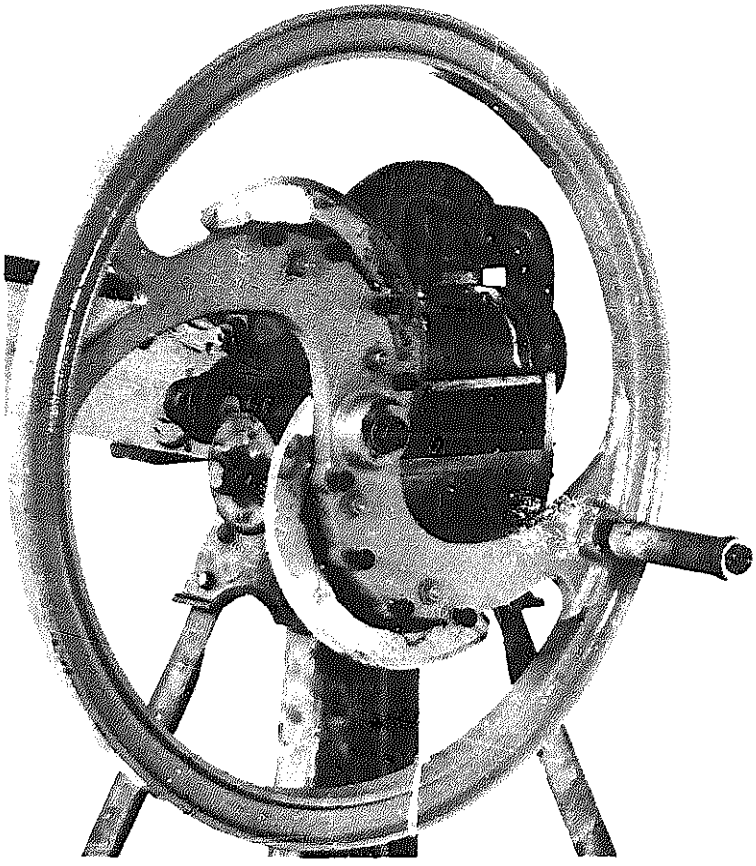
Ajanta Silage Cutter

This implement has two blades and runs on ball bearings. The worm gear drive can be set to either of two fodder-cutting lengths with segments ranging from 5/8 inch (15.9 millimeters) to 7/8 inch (22.2 millimeters). The output for dry fodder is 200 to 250 kilograms per hour and 250 to 300 kilograms per hour for green fodder.



Ajanta Ensilage Cutter
Mohan Singh Harbhajan Singh

Mohan Singh Harbhajan Singh
G.T. Road, Goraya 144 409
Distt. Jullundur, India



The shear-plate of a silage cutter, and the pair of knives mounted on the hand-operated flywheel.
R. Hunt

Simplex Silage Cutter

This model has 7½ inch by 2¾ inch knives, and a large flywheel.

R. Hunt & Co., Ltd.
Atlas Works, Earls Colne
Colchester, Essex CO6 2EP, U.K.

Renson et Cie Grass Cutter

This unit has a cast-iron body and base plate with semisteel gearing. Four adjustable blades are mounted on a 450 millimeter hand-cranked flywheel. It weighs 13 kilograms and cuts 3-millimeter segments.

Renson et Cie
B.P. 14
59440 Landrecies, France

Poultry Feed Cutter

This unit is similar to a small chaff cutter and is fitted with a 425-millimeter diameter flywheel.

Ernest H. Johnson (Pty.) Ltd.
Box 7536
Johannesburg 2000, South Africa

Chaff Cutter

This all-cast-iron, manually operated chaff cutter runs on two ball bearings and employs a flywheel.

Rajasthan State Agro Industries Corp., Ltd.
Virat Bhawan, C-Scheme
Jaipur 302 006, Rajasthan, India

POWER-OPERATED SILAGE CUTTERS

The feeding mechanism of the power-operated silage cutter does not differ much from the hand-operated type, although the cutting mechanism itself may differ a bit. Two types of

cutting heads are available, a cylinder type and a flywheel type. In both cases, a fan is provided for blowing the cut material into a silo through a vertical blower pipe. A power-operated silage cutter performs three functions—feeding the material into the blades, cutting, and elevating material into a storage bin.

The capacity of a silage cutter depends on the width and height of the throat, length of cut, number of knives, and speed of operation. One-half inch is an average length of cut, but this can be regulated by the speed of the apron and feed rollers. Faster feeding results in longer cuts while slower feeding will give correspondingly shorter cuts.

SOURCES OF POWER-OPERATED SILAGE CHOPPERS

Nogueira

This model cuts all kinds of forages into lengths varying from 4 to 32 millimeters. It will throw the cut product to a height of 10 meters while the adjustable outlet allows it to be deposited in any preselected place.

Irmaos Nogueira S.A.
Rua 15 De Novembro, 781
Caixa Postal, 7
Itapira, Est. Sao Paulo, Brazil

Atlas

Fitted with forward, stop, and reverse action and controlled by a safety stopping lever, the Atlas comes supplied with two pairs of change wheels which will cut a range of lengths from ¼ to ¾ inch. The output for ¼ inch lengths ranges from 7 to 15 hundredweights per hour, depending upon the blades used.

R. Hunt & Co., Ltd.
Atlas Works, Earls Colne
Colchester, Essex CO6 2EP, U.K.

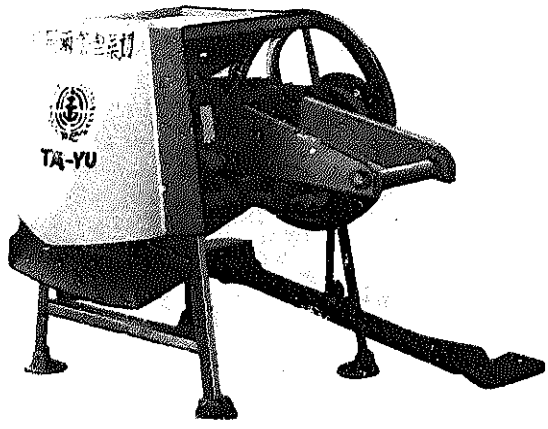
Laredo Chopper

This unit works coupled to the three-point hitch of a tractor or powered by a stationary engine—electric or fuel. It is a combination hammer mill–silage chopper capable of producing from 220 pounds of fine corn flour to 2 tons of chopped grass in an hour.

Laredo
Rua 1° de Agosto
11-67—17.100
Bauru (SP) Brazil

Tien Chien Silage Chopper

The Ta-Yu Silage Cutter and Potato Slicer is treadle-powered but can be operated with a ¼ to ¾ h.p. motor. It weighs 84.6 kilograms, measures 27 by 34 by 39 inches, and produces at a rate of approximately 300 to 500 kilograms per hour.



Tien Chien Treadle Power Ensilage Cutter and Potato Slicer.
Tien Chien Enterprises

Tien Chien Enterprises Co., Ltd.
P.O. Box 20-18
Taichung, Taiwan, R.O.C.

CeCoCo Chopper

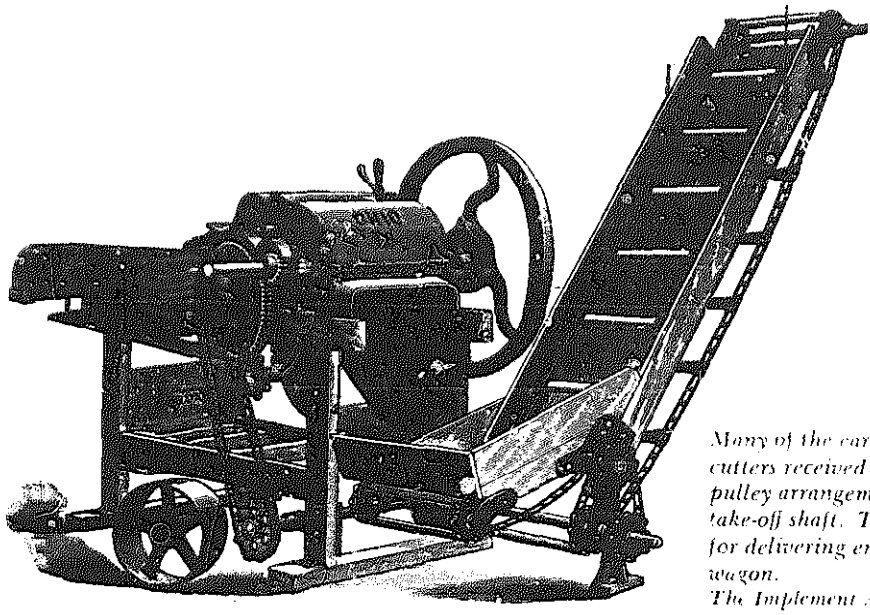
The chopping length of this unit varies from 9 to 51 millimeters utilizing a 2.5 to 4.0 h.p. motor. It has a capacity of up to 4.9 tons per hour.

CeCoCo Chaff Cutter

This power unit comes in four models ranging in power requirement from ¼ to 2 h.p. for output capacities of 300 to 800 kilograms per hour. The cut is freely adjustable, and the blades are made of sheer steel for long-lasting sharpness.

CeCoCo Silage Cutter

The silage cutter is designed to blow chopped material into a high storage space. The



Many of the early power-operated silage cutters received their power from a V-belt and pulley arrangement from a tractor power-take-off shaft. This model has a conveyor for delivering ensilage to a high bin or into a wagon.
The Implement Age, 1894

SPECIFICATIONS OF THE CECOCO SILAGE CUTTER

Power Required	rpm	Capacity ton/hour		Cutting Length in millimeters	Net Weight
		Corn	Straw		
5-6 h.p.	800	6.0-8.0	1.8-2.3	10, 16, 22, 32, 41, 76	265 kg
3-4 h.p.	770	3.5-4.5	1.3-1.7	same	180 kg
2-3 h.p.	770	2.5-3.5	0.9-1.3	6, 13, 19, 32, 54, 85	145 kg
1-2 h.p.	750	1.5-2.5	0.9-1.1	13, 22, 35, 64, 102	115 kg
1-2 h.p.	750	1.0-1.5	0.8-0.9	8, 21, 38, 110	100 kg

knives are easily removed for sharpening and the shear-cutter-bar has double cutting edges which can be reversed when one side is worn out.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka, Pref. 567, Japan

ROOT AND VEGETABLE CUTTERS

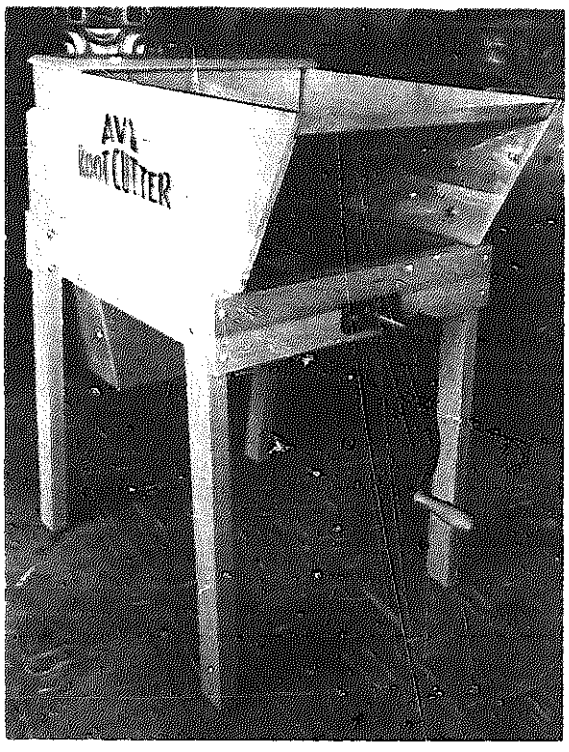
The root and vegetable cutter is a very simple tool for slicing potatoes, turnips, sugar beets, carrots, and other root crops into small pieces suitable for animal feed or compost. It is not designed to handle branches or heavy brush. In practice, the hopper is filled with semihard fruits or vegetables which are then sliced and shredded by the action of a heavy, cast-iron wheel with a number of small cutters attached to it.

SOURCES OF ROOT CUTTERS

A.V.I. Root Cutter

The 18 inch, cast-iron disc of this hand-operated cutter is mounted on a 1 inch diameter shaft. Cutter teeth are of a heavy-gauge stainless steel. The basic frame is made of oak, the hopper of alder or Western maple. The unit weighs approximately 75 pounds and measures 40 by 24 by 36 inches.

American Village Institute
440 Meyers St.
Kettle Falls, WA 99141



The AVI Root Cutter

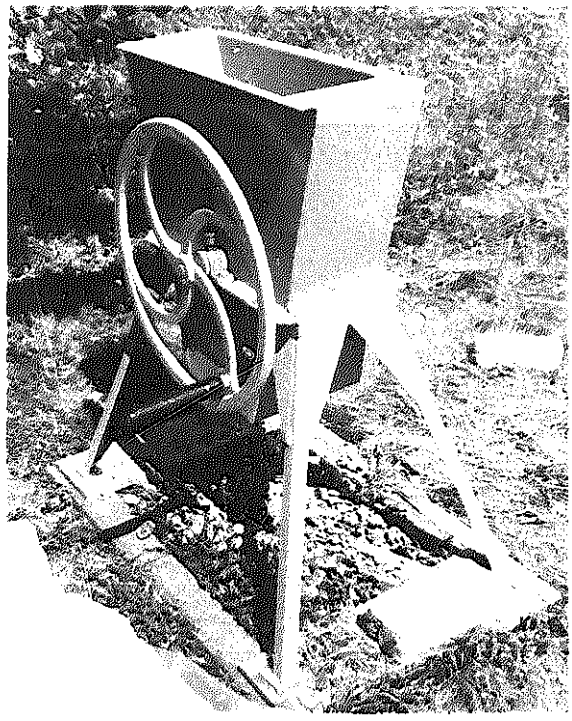
Hand-Powered Root Cutter, Series B

This unit is made of cast iron, has a cutting cylinder measuring 200 by 380 millimeters, and has a flywheel diameter of 600 millimeters for a hand-powered operation. Weight: 100 kilograms.

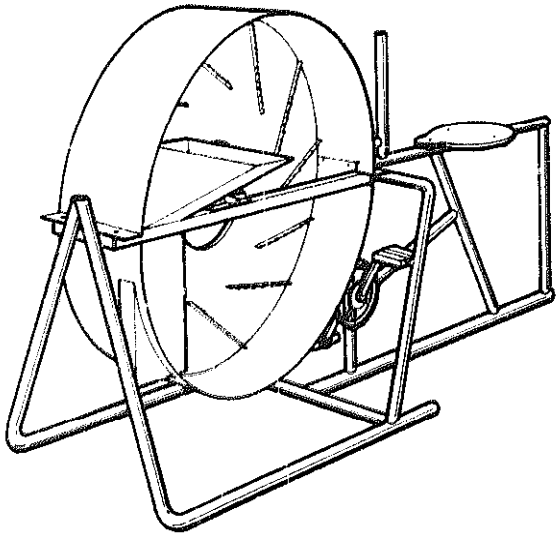
Renson et Cie
B.P. 14
59550 Landrecies, France

Hand-Operated Root Cutter

Of Polish manufacture, this machine is hand operated and has an output of 500 kilograms per hour. At the base of the hopper are a pair of concave discs facing each other, each with 26 short, curved blades projecting from the surface. The crank is on a flywheel which helps rotate the cones at a slow, steady speed. The hopper can hold 22 kilograms of harvested roots, and guide plates ensure that they are pressed by their own weight against the moving blades. As the discs are rotated, the blades gouge out short chips which then drop through the opening below the discs.



Polish Hand-Operated Root Cutter
David Scott



The Intermediate Technology Development Group designed this pedal-powered cassava grinder for use in their work at Zaria, Nigeria. London-based Intermediate Technology Publications carries the plans.

United Nations Division of Narcotic Drugs
Palais Des Nations
Geneva, Switzerland

SORGHUM AND SUGARCANE PRESSES

Pressing the juice from nonwoody plants like sorghum and sugarcane requires only simple tools and yields a sweet extract which can be processed for use as table sugar. The most common technique for pressing sorghum and sugarcane involves passing the stalk between two rollers, similar to the rollers on an old wringer washing machine. The weaker units require passing the stalk through a number of times, or splitting or pounding the material with a hammer before pressing.

If you're interested in improvising to build your own press, you may want to consult a book called the *Lik Lik Buk* from Papua, New Guinea (available from VITA, 3600 Rhode Island Avenue, Mt. Rainier, MD 20822). It illustrates a simple two-man sugarcane crusher that has no gears but has an adjustment screw at the top. Sugarcane is passed through the crusher three or four times, with the adjustment screw being tightened each time. The rollers are made of four-inch galvanized pipe, eight inches long; shafts are one-inch mild steel, and bearings are of hardwood. The top pair of bearings slides up and down depending upon the thickness of the stalk. Another unit has preset, spring-loaded rollers which require no further adjustment.

This setup may sound suspiciously like an old wringer washer to you, but heed this word of warning from the *Lik Lik Buk*: "If you think you can crush effectively with an old clothes mangle or wringer, you're wrong. Save yourself the bother. The springs aren't strong enough and if they are, the rollers might break."

SOURCES OF SUGARCANE AND SORGHUM PRESSES

Hand-, animal-, and engine-powered crushers are available for crushing sorghum and sugarcane. For convenience of the drive layout, it is usual to employ vertical rollers in animal-powered crushers and horizontal rollers in hand- and engine-powered machines. Hand crushers are normally used only for domestic purposes and extract a rather small percentage of the sap. Animal- and engine-powered crushers can employ higher crushing pressures and obtain better extraction percentages.

TAPPING SWEET SORGHUM

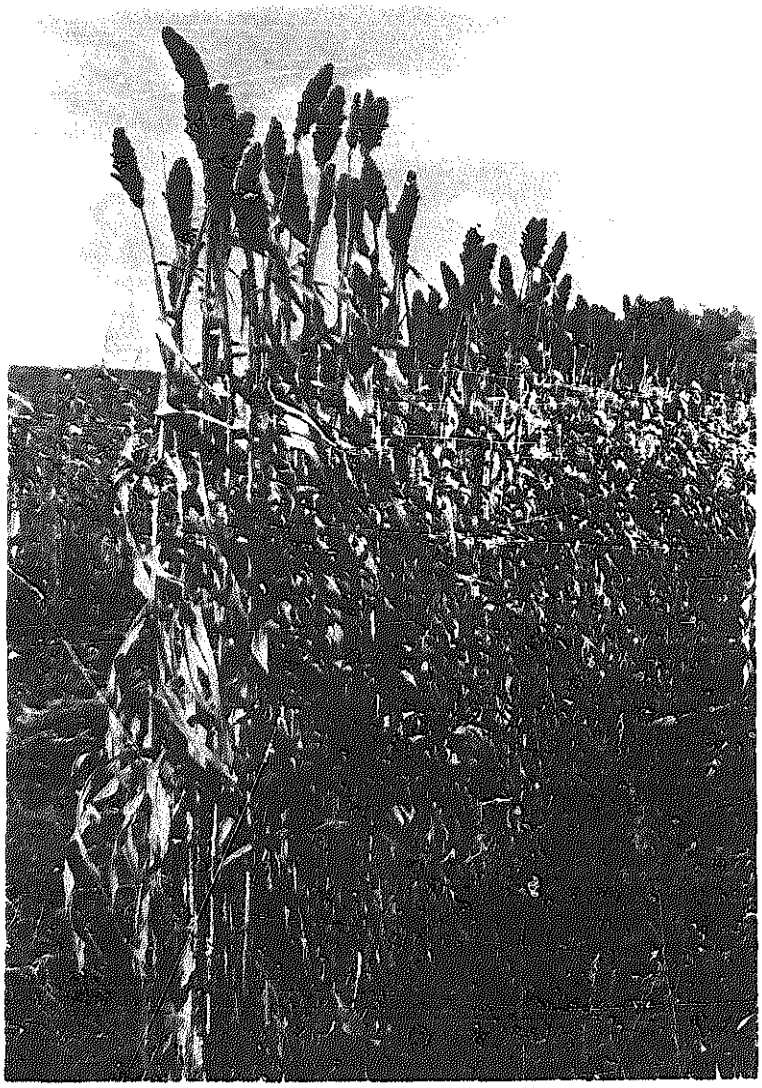
The tedious, old-fashioned production of sorghum syrup is rather like an old soldier: it keeps fading away but never dies. In fact, sweet sorghum may be making a comeback. Gardeners and homesteaders know it provides a tasty substitute for store-bought sweeteners. They also think that sorghum may be a practical cash crop they can grow for a sideline income without too much competition from big commercial farmers, since harvesting is still a process done pretty much by hand.

Now that the USDA (at the Agricultural Research Service Food Crops Utilization Research Lab in Weslaco, Texas) has found a way to remove starch from sweet sorghum so that it can be made into raw sugar, and not just syrup, small growers are bound to get even more interested. Experts say that the United States could replace 30 percent of the sugar it now imports with its own sorghum sugar, once the destarching process is perfected.

Gene Logsdon of Ohio grew two rows of sweet sorghum last year, each about 150 feet long, to see how well it would grow in the North. "I'm interested in it strictly as a northern source of sweetening," he explains. "I don't have bees yet, and only two maple trees large enough to tap. I wanted another alternative to buying sugar."

Drew Langsner in North Carolina looked more at sorghum's possibilities to add income to his homestead. "We were told that we could make up to 120 gallons of molasses per acre which could be sold direct to customers for as much as $12 a gallon," he says. "Moreover, the plant has few insect enemies here and is not critically affected by blights. Also, not only do you get the syrup, but the seed heads and leaves can be used for livestock feed."

Actually, sorghum in some areas can produce a good deal more molasses than what the Langsners



Sorghum is planted the same time corn is, about one to two inches deep. Begin cultivating right over the row two days after planting, when the weeds are beginning to germinate, but the sorghum is not yet up.

were shooting for—three times that amount. Or it can produce a good bit less and sell as low as $5 per gallon, depending on supply and demand. But any way you look at it, with a little luck and a *normal crop, sweet sorghum ought to gross at least $1,000 per acre and maybe as much as $2,000 per* acre—or enough money left over after expenses to repay you fairly well for the hard work involved.

The Logsdons didn't know precisely when to harvest their sorghum for juice, so they relied on advice from Amish farmers who grew it. The farmers said to wait until the seed heads had turned from green to reddish brown, when the seeds are past the milky stage, but still soft. However, the stalks didn't have to be cut immediately at that stage. Any time from then on was okay, so long as the harvest was finished before hard frost hit the plants.

At any rate, the first harvest step is stripping off the leaves, a job that's more easily done when the stalks are still standing. Wear gloves and just slide your hands down the stalks, knocking off most of the leaves. It doesn't hurt for the stalks to stand stripped of their leaves for a week.

"Stripping the leaves off is drudgery," says Langsner, "especially when, as in our case, many of the stalks have fallen over. We bind about half the stripped leaves into bunches to dry for winter livestock feed, and the rest we let fall on the ground for mulch."

Next, the stalks are cut and the seed heads lopped off. The Logsdons just cut the stalks with a corn knife as they do corn and pile them in bundles beside the row. Then they carry the bundles to the pickup truck, whack off the heads from an entire bundle with one blow of the corn knife, and load the stalks on the truck.

The seed heads should be spread out in the barn for drying, then stored for feeding. They need not be threshed except for grinding into flour. Rolling a seed head vigorously between the palms of your hands will easily thresh out the grains. But the seed heads can be fed directly to chickens, rabbits, and other livestock.

From their half acre, the Langsners harvested 102 bushels of seed heads—or roughly about 30 bushels of seed. That much nutritional energy bought at the feed store in the form of conventional grains would cost at least $100, so the seed alone may justify the labor involved.

Finding a press, if you don't have one, is not as difficult as it might seem, even in the North. They're still around—just keep asking. Gene Logsdon found at least three within easy driving distance of his place, but had you asked him two years ago, he'd have said there were none. Once you haul your stalks to the press, don't worry if the man can't get yours pressed and boiled down right away. The canes can lie two weeks without any noticeable loss of juice.

Many presses are now powered with motors, but a surprising number are still turned by horse or mule—the animal walks in a wide circle, pulling a sweep that turns the gears that make the rollers run. The operator shoves the stalks through the rollers, which squeeze the juice into a waiting barrel through a screen. The crushed stalks fall to one side in a pile. They can be used for mulch or composting, or even fed to cattle as silage if laced with some of the syrup skimmings produced during the boiling-down process.

A sorghum cooker can be built at home. The farmer who boils the Logsdons' sorghum made his own cooker—a cement fireplace about eight feet long and two feet wide, with a ten-foot chimney at one end and a roof overhang to protect the cooker from rain. The fire is built near the open end of the fireplace, and the draft pulls the heat evenly under the cooking pan and out the chimney.

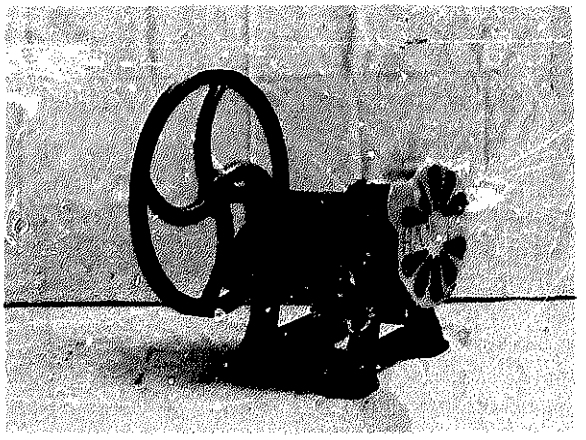
"The pan can be a very simple affair made of 2-by-8 inch boards for sides and ends and a sheet metal bottom," says one expert, "the whole pan should be about six feet long and two feet wide to fit nicely over the fireplace. Don't use galvanized metal, because the zinc coating on it might react adversely with the acids in the syrup."

SOURCES OF SUGARCANE PRESSES

CeCoCo Hand Sugarcane Squeezer

Employing three rollers to do the squeezing, this unit can be powered by hand or by a ½ h.p. motor for a production capacity of 115 kilograms per hour of cane. CeCoCo also manufactures larger cane mills with capacities ranging from 6 to 15 tons of cane per hour.

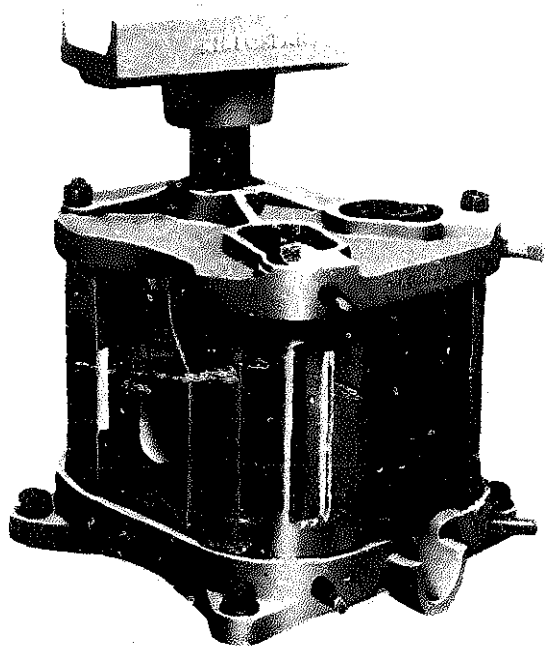
CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan



CeCoCo Hand Sugar Cane Squeezer

Kumar Cane Crusher

This is a vertical three-roller sugarcane crusher which can be driven with one pair of animals. Its capacity falls between 300 and 350 pounds of cane per hour (136 to 158 kilograms per hour). Two other units with higher capacities are available—the Karmat and Kamal vertical three-roller crushers.



Kumar Cane Crusher

Kumar Industries
Edathara Post, Palghat District
Kerala State, South India

Konya-a Cane Crusher

This is a horizontal crusher designed to be operated by a 4 or 5 h.p. motor. It has a crushing capacity of 800 to 1,000 pounds per hour (365 to 455 kilograms per hour). Higher capacity units with three or five rollers are also available.

Kirloskar Brothers, Ltd.
Udyog Bhavan, Tilak Rd.
Poona 411 002 India

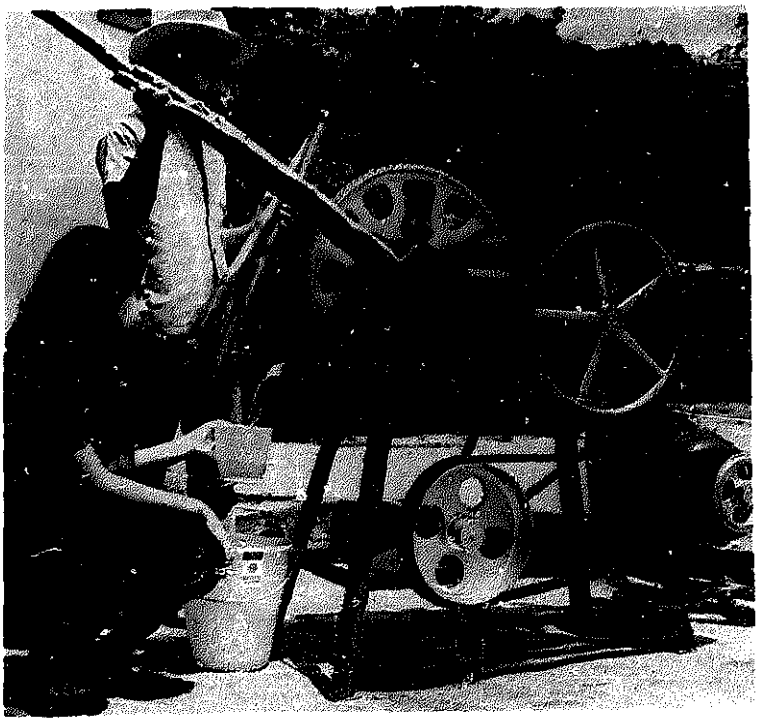
Raja Horizontal Sugarcane Crusher

With a crushing capacity of 1,500 to 1,700 kilograms per hour and a juice extracting capacity of 1,300 to 1,600 liters per hour, this machine requires a 5 to 7½ h.p. motor to run it.

Raja Trading Co.
P.O. Box 250
Madra 600 001 India

Nogueira Sugarcane Crusher

Constructed of rust-resistant iron, the Nogueira crusher can be powered by a 2 h.p. electric, 5 h.p. gasoline, or 3 h.p. diesel engine. The 95 by 165 millimeter rollers are designed for



Nogueira Sugarcane Crusher
CIMAG

self-feeding so that the cane does not have to be forced through the rollers. Adjustments and maintenance on the 125 kilogram unit are simple. It has a production capacity ranging between 300 and 400 liters per hour.

CIMAG, Comercio & Industria De Maquinas Agricolas LTDA.
Rua Padre Rogue n.° 1.840
Mogi-Merim S.P., Brazil

SEED OIL PRESSES

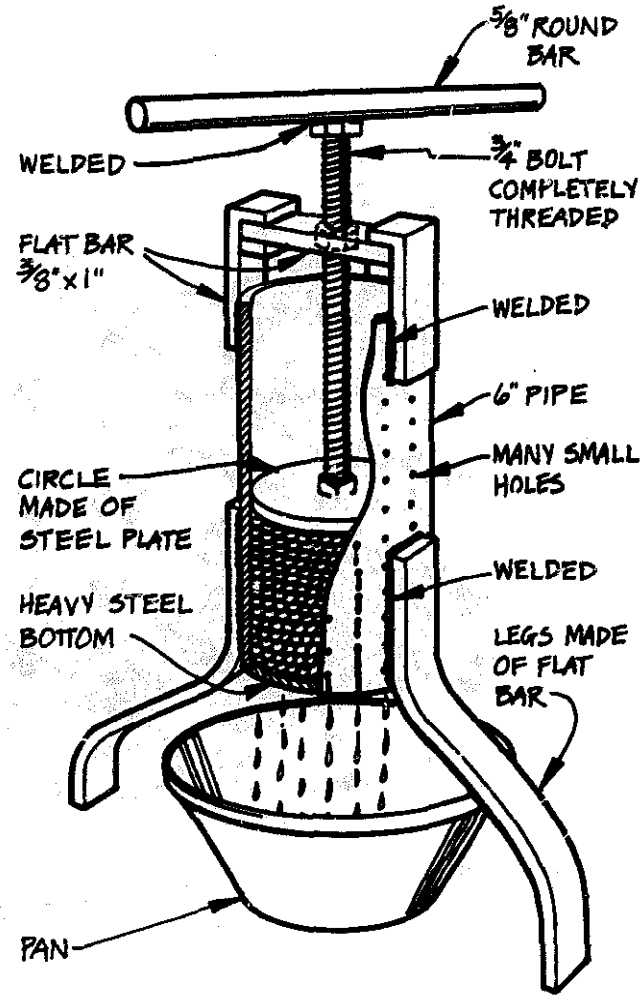
Pressing oil from seeds requires much more force than what's needed to press cane or sorghum. Prior to pressing, the seeds are ground or mashed and often heated in water until the water boils. Some oil may have collected on the surface of the water; this should be skimmed off and saved. The ground, cooked seed mash is then put in a cloth bag and pressed. A second boiling and pressing could yield a bit more oil.

Unfortunately, we have not been able to locate any sources of oil presses presently under manufacture in the United States, although many people are seeking such units.

SOURCES OF OIL PRESSES

***Lik Lik Buk* Press**

The Papua, New Guinea *Lik Lik Buk* (distributed by VITA, 3600 Rhode Island Avenue, Mount Rainier, MD 20822) pictured this oil press design as a build-it-yourself suggestion for villagers. It was designed as a sturdy unit which will exert a great deal of pressure on a small



Hand Oil Press

amount of seeds. Reducing the capacity raises the amount of pressure generated for any given torque on the operating arms and downward thrust of the piston.

CeCoCo Oil Mill

CeCoCo provides equipment for all stages of the oil-expelling process. A Seed Scorcher is used for drying the product, to reduce its moisture content to 4 or 5 percent. The oil expelling is done by tightening a screw worm, either by hand or motor. Finally, a filter press is used for filtering the raw crude oil through filter cloths and papers. This system works for many kinds of beans and seeds including rape, mustard, sesame, cotton, and sunflower seeds, and palm pericarp, peanuts, castor beans, and dried coconut, or copra.

SPECIFICATIONS FOR CECOCO OIL MILL MACHINERY

Machine's Name	Type	Capacity per hour	Power Required	Rpm	Dimension in mm			Net Weight	Gross Weight	Shipping Measurement
					Height	Width	Length			
Crusher	AA	600 kg	2 h.p.	1,400	560	395	640	75 kg	115 kg	10 cu. ft.
Seed Scorcher	L	5 bu.	1 h.p.	150	1 ft. × 4 ft. φ Vessel			436 kg	633 kg	57 cu. ft.
	S	3 bu.	½ h.p.	150	1 ft. × 3 ft. φ Vessel			115 kg	160 kg	31 cu. ft.
Oil Expeller	H-3	3-6 kg	Hand	Proper	520	260	600	27 kg	43 kg	4 cu. ft.
	New 52	45-55 kg	3 h.p.	300	630	520	1,000	150 kg	200 kg	14 cu. ft.
	New M	120-140 kg	5 h.p.	350	700	560	1,050	170 kg	220 kg	22 cu. ft.
	H-54	150-180 kg	7½ h.p.	600	700	700	1,250	430 kg	520 kg	31 cu. ft.
	HX-200	250 kg	10 h.p.	450	980	800	1,920	880 kg	1,080 kg	90 cu. ft.
	C	600-800 kg	15-20	1,000	1,180	960	3,000	3,600 kg	4,000 kg	120 cu. ft.
Filter Press	A	12 gal.	½ h.p.	170	7″ × 7″ × 10″ chamber			125 kg	175 kg	9 cu. ft.
	B	40 gal.	1 h.p.	200	12″ × 12″ × 14″ chamber			340 kg	500 kg	25 cu. ft.

When inquiring about an oil mill plant, please let CeCoCo know: (a) name of raw material to expel oil; (b) desired capacity per hour or 24 hours in raw material; (c) how you will use the oil produced; (d) whether you need group-driven or individual-driven equipment: if motor driven, also specify phase, voltage, frequency, current, and other details.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Table Oil Expeller

Four models of oil expellers are available from S. P. Engineering. Two presses, each with a 3 h.p. motor, yield 30 or 40 kilograms per hour, and two with 5 h.p. motors yield 50 or 55 kilograms per hour. All four units operate at 450 rpm.

S. P. Engineering Corp.
P.O. Box 218, 79/7 Latouche Road
Kanpur, India

COFFEE PROCESSING MACHINERY

Coffee cherries, the ripened fruit of the coffee shrub, each contain two coffee beans. Two different techniques are utilized to remove the covering and pulp to produce clean coffee beans, the desired product.

The wet process begins with the pulping of the fruit by a pulping machine or pulper. Additional operations involving fermentation and washing may be needed to remove the pulp residue that remains. The seeds are then dried in the sun or in driers, until the moisture content has reached 12 percent. The seed parch-

ment is then removed in additional mechanical operations.

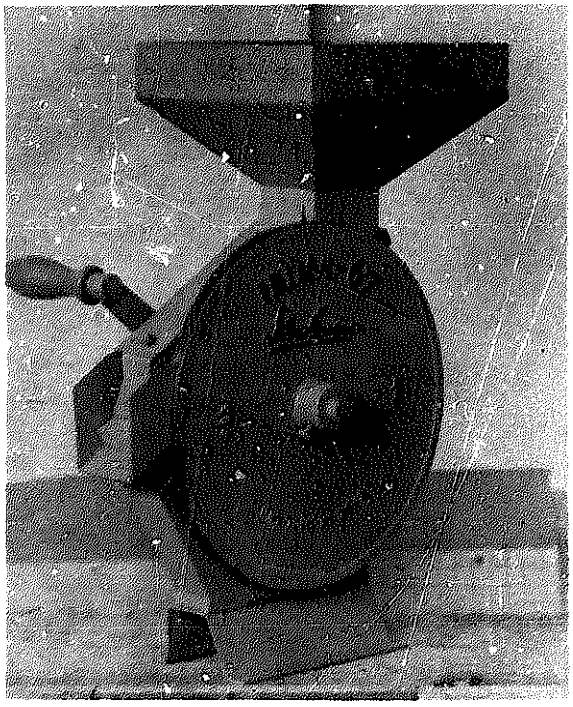
The dry process begins with the drying of the ripened fruit, either in the sun or driers. When the fruits are dry, hullers are used to remove the seed coverings. Graders are then used to separate varieties, sizes, and shapes of coffee beans offering a standard of sale.

SOURCES OF COFFEE PULPERS

IRIMA-67 Disc Coffee Pulper

This small machine pulps the coffee by squeezing the cherries between the rotating disc and the fixed pulping chop. The disc is of smaller diameter than standard and carries bulbs on one face only. Normally, the disc has cast-iron bulks of No. 75 pattern suitable for Robusta and Arabica coffees. Alternative discs can be supplied for use with Arabica and Liberica varieties.

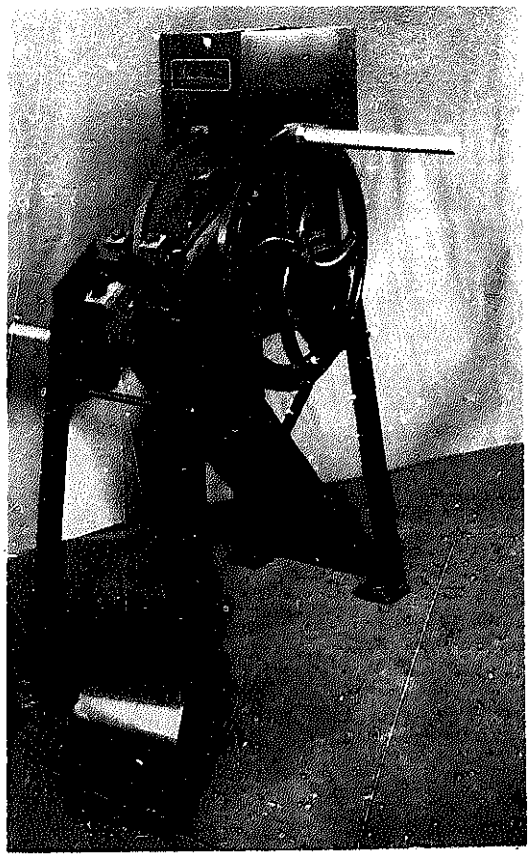
The capacity of the machine is 594 to 792 pounds (270 to 360 kilograms) an hour of ripe coffee cherries, which should be fed into the machine with water on the same day as it is picked. The machine weighs 55 pounds (25 kilograms).



IRIMA-67
John Gordon

DG Disc Coffee Pulper

The DG coffee pulper is a single-disc machine which employs pulping bars and a pulping disc. The bars are straight, with a renewable steel edge, and are fitted with a cam device for ease in setting the chop relative to the disc. It has an index to enable the setting to be found again easily, and the chops are readily removable for cleaning.



DG Disc Coffee Pulper
John Gordon

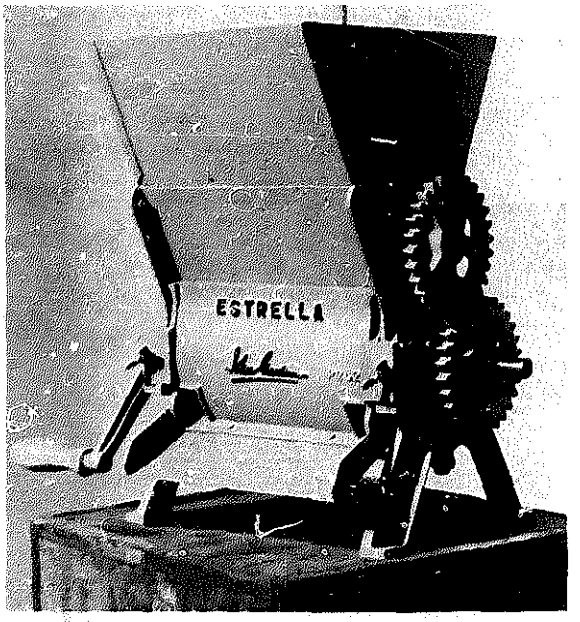
For treating Robusta and Arabica coffees, copper discs No. 75 or cast-iron bulbed discs No. P75LC are available. For other varieties, copper discs only are supplied, No. 71 for Liberica and No. 77 for coffees allied to Liberica but slightly smaller, or for large Arabica.

The machine can pulp up to 1,540 pounds (700 kilograms) of ripe coffee cherries per hour.

They should be fed to the pulper with an abundance of water on the same day as they are picked. The DG pulper has a net weight of 294 pounds (133 kilograms).

Estrella Coffee Pulper

This is a cylindrical coffee pulper, which squeezes the coffee cherries between the rotating, embossed cylinder and the fixed breast. It is made in two models. In one, a stirrer is fitted in the hopper, which has no stone trap. In the other, the hopper has a stone trap but no stirrer. In both models, the distance between the breast and the cylinder is adjustable. The machine is suitable for Arabica and Robusta coffees, but not for Liberica. It can pulp up to 594 pounds (270 kilograms) of ripe coffee cherries an hour depending on type and condition. The coffee should be pulped the same day as it is picked and fed to the machine with water. The machine with stirrer weighs 103 pounds (47 kilograms) and without stirrer, 85 pounds (38 kilograms).



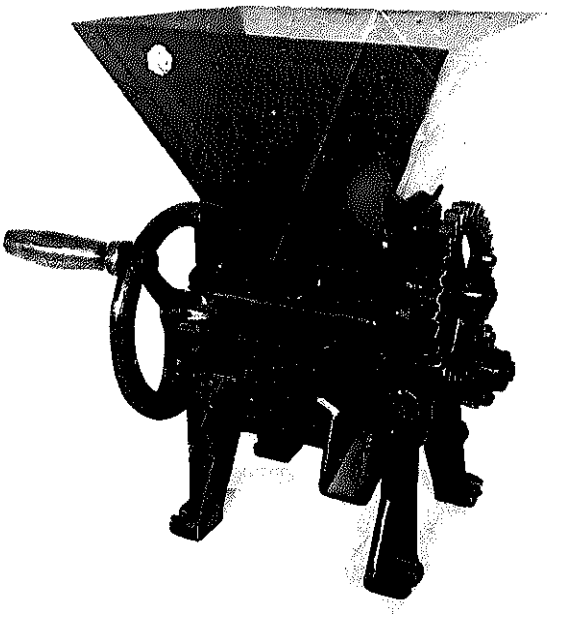
Estrella Coffee Pulper
John Gordon

MTOTO Coffee Pulper

This small coffee pulper is intended for use on small plantations but is also useful for treating the first crop on larger plantations. It is of the cylindrical type. The machine is suitable for Arabica and Robusta coffees, but not Liberica, and can pulp up to 100 pounds (45 kilograms) of ripe coffee cherries each hour. The cherries should be fed into the machine with water on the day they are picked. The working surface of the breast is machined, and the iron barrel has a renewable embossed cover.

A different version of the MTOTO called the Starlet Major is available without a stirrer but with a stone trap.

The machine weighs 34 pounds (15.5 kilograms).



MTOTO Coffee Pulper
John Gordon

All the above pulpers are available from:
John Gordon & Co. (Engineers, Ltd.)
196a High St.
Epping, Essex, England

Atom Coffee Pulper

This pulper is suitable for Arabica and Robusta coffees, but not suitable for Liberica coffee. Its output of ripe cherry pulp is 55 kilograms per hour. Weight: 15 kilograms.

McKinnon Number 1 Disc Pulper

This model is fitted with ball bearings, cast-iron disc, flywheel, and handle for hand operation.

Both models available from:
William McKinnon & Co., Ltd.
Spring Garden Iron Works
Aberdeen, AB9 LDU, U.K.

Baby Pulper

The Baby Model No. 2 yields 127 kilograms per hour and No. 2½ yields 254 kilograms per hour. No. 2½ is hand-operated and can be supplied with a flywheel grooved for V-belt power drive.

Sunbeam Pulper

This unit is power-driven with an output of 550 to 650 kilograms per hour when driven by a 1 h.p. engine.

The above models are manufactured by:
E. H. Bentall & Co., Ltd.
Maldon
Essex, CM9 7NW, U.K.

SOURCES OF COFFEE HULLERS AND SEPARATORS

Engelberg Huller Company carries two sizes of coffee hullers and separators. These ball- or roller-bearing machines will hull coffee in the whole (coco) cherry or parchment form, separate and discharge the hulls, and deliver cleaned coffee beans.

Model No. 1 has a capacity of 1,600 pounds per hour for pulped coffee, and uses 10 to 12 h.p. Model 0, using 15 to 18 h.p., has a capacity of 3,400 pounds per hour. This larger model is also available with tight and loose pulleys.

Engelberg Huller, Co., Division
U.S. Route 11, P.O. Box 277
Factoryville, PA 18419

Number 5 African Huller

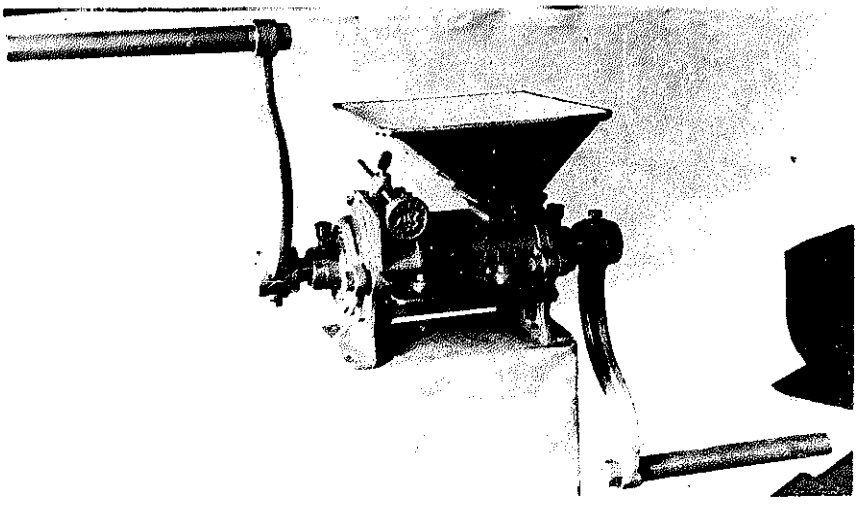
This model's output of clean coffee from dry cherries is 114 kilograms per hour. Output of clean coffee from parchment coffee is 127 kilograms per hour.

Power required is 5 h.p. The No. 5 weighs 216 kilograms. Larger models are also available.

E. H. Bentall & Co. Ltd.
Maldon
Essex, CM9 7NW, U.K.

Number 10 Africa Coffee Huller

This coffee huller can be conveniently operated by hand power and is ideal for small-scale farmers. It is normally fitted with two handles but it can also be supplied fitted with a pulley 229 millimeters in diameter by 76 millimeters wide, requiring 1.5 h.p. The machine can shell dry cherry coffee and also parchment coffee. It will treat Arabica, Robusta, and Liberica varieties,



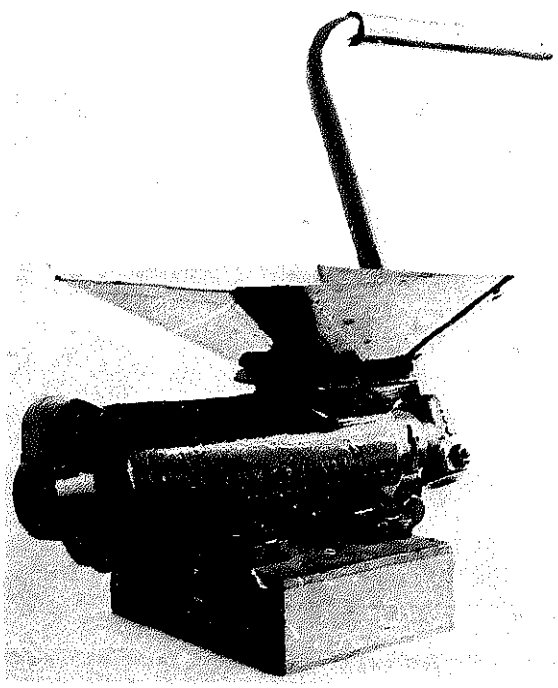
No. 10 Africa Coffee Huller
John Gordon

although with hand power, dry cherry Liberica coffee is too difficult to shell. The machine is fitted with two adjustable hulling blades, a feed slide and a weight to regulate the pressure on the discharge door, all of which are adjustable to obtain optimum performance. A perforated plate, which is easily detachable for cleaning purposes, is fitted to the bottom of the machine. Dust and small flakes of shell pass through it. The coffee is delivered shelled but mixed with large flakes of shell; it should be winnowed afterward.

Dry cherry Arabica coffee can be shelled at the rate of 48 pounds (22 kilograms) of clean coffee an hour, and parchment Arabica coffee at the rate of 79 pounds (36 kilograms) an hour. For Robusta, these outputs are about 30 percent more, and for Liberica about 30 percent less. The machine has a net weight of 95 pounds (43 kilograms).

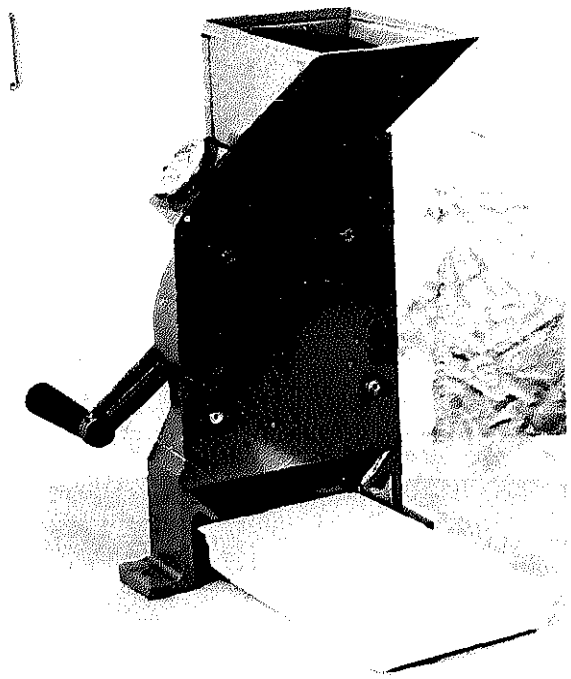
Bukoba Coffee Huller

This small huller is designed for shelling dry cherry coffee, but it will also shell parchment coffee. Its use is indicated for small-scale farmers, and as a sampling machine for larger mills.



Bukoba Coffee Huller
John Gordon

The machine is strongly constructed and has no adjustments. The coffee is simply fed to it and the handle turned. The shelled coffee is discharged mixed with the shells and dust and must then be winnowed and sieved. Dry cherry coffee can be shelled at the rate of 20 pounds (9 kilograms) of clean coffee an hour. Parchment coffee can be shelled at the rate of 60 pounds (27 kilograms) an hour. The coffee must be quite dry and crisp when fed to the machine, which is not suitable for the treatment of Liberica coffee. The net weight of the machine is 29 pounds (13.5 kilograms).



Limprimita Coffee Sheller
John Gordon

Limprimita Coffee Sheller

This is a small huller which is very useful in coffee-cleaning mills and also to those coffee buyers who purchase parchment or dry cherry coffee. According to the manufacturer, the advantage of this model over other sampling machines is that any quantity from one bean to several kilograms can be shelled rapidly, completely, and safely.

A ribbed roller operates in conjunction with an adjustable, flexible block. The lightest pres-

sure consistent with good performance is applied by adjusting this block. The roller is turned before the coffee is fed into the machine, and this should be done gradually and evenly. The coffee is discharged mixed with the loose shells, and should then be winnowed. The machine should be fixed firmly to a table. It is 17 inches (43 centimeters) high and its net weight is 29 pounds (13 kilograms).

The above hullers are manufactured by:
John Gordon & Co. (Engineers, Ltd.)
196a High St.
Epping, Essex, England

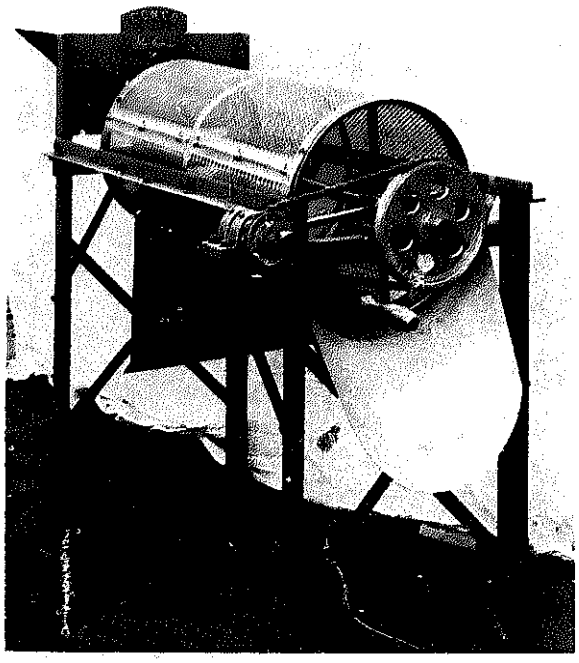
SOURCES OF COFFEE GRADERS

Congo Coffee Grader

This little grader is especially suitable for use in an installation of small, hand-driven coffee hullers. Its output is 110 pounds (50 kilograms) an hour. The cylinder is composed of a perforated plate with two sets of perforations, thus giving three grades. The grades may be determined to suit the requirements of the planter, and about 2 pounds (1 kilogram) of coffee should be sent to the manufacturer when passing the order to make sure that the most suitable perforations are provided. The perforated plate is easily detachable. With spare plates of different perforations, it is possible to treat several varieties of coffee in the same machine. Plates are available with three perforations, thus giving four grades, but the output is less. The shafts are mounted in ball bearings.

A larger grader of the same design, having a capacity of 495 pounds (225 kilograms) an hour, is also available, and can be supplied for hand power or complete with small electric motor. The small grader weighs 187 pounds (85 kilograms), the larger, 495 pounds (225 kilograms).

John Gordon & Co. (Engineers, Ltd.)
196a High St.
Epping, Essex, England



Congo Coffee Grader
John Gordon

MAPLE SUGARING EQUIPMENT

Equipment for collecting and processing maple syrup is so very specialized that all the necessary implements can generally be obtained from the same source. For collecting, there are plugs, sap bags, collection tubs, and buckets. Evaporators and skimmers are used for processing, and for the small commercial venture, there is a need for molds, cans, bottles, and filters.

Instead of itemizing the tools and accessories available from the different companies, we recommend you send for their fully illustrated catalogs. Instruction books are available for the novice maple sugarer from these companies:

G. H. Grimm Co., Inc.
Box 130
Rutland, VT 05701

Leader Evaporator Co., Inc.
25 Stowell St.
St. Albans, VT 05478

Small Brothers, Inc.
P.O. Box 160
Dunham, Quebec JOE 1MO, Canada

Les Specialites Techniques De Valcourt, Inc.
746 rue St. Joseph, C.P. 68
Valcourt, P.Q. JOE 210, Quebec, Canada



Down to a science: Ralf Clark and Fred Behringer of Waterford, Connecticut, keep the wood stacked high a year ahead of time to dry, use it as a barrier against the weather, and have the system arranged with pulleys so that their sugaring project stays a one-man job.

GOLD IN THE TREES

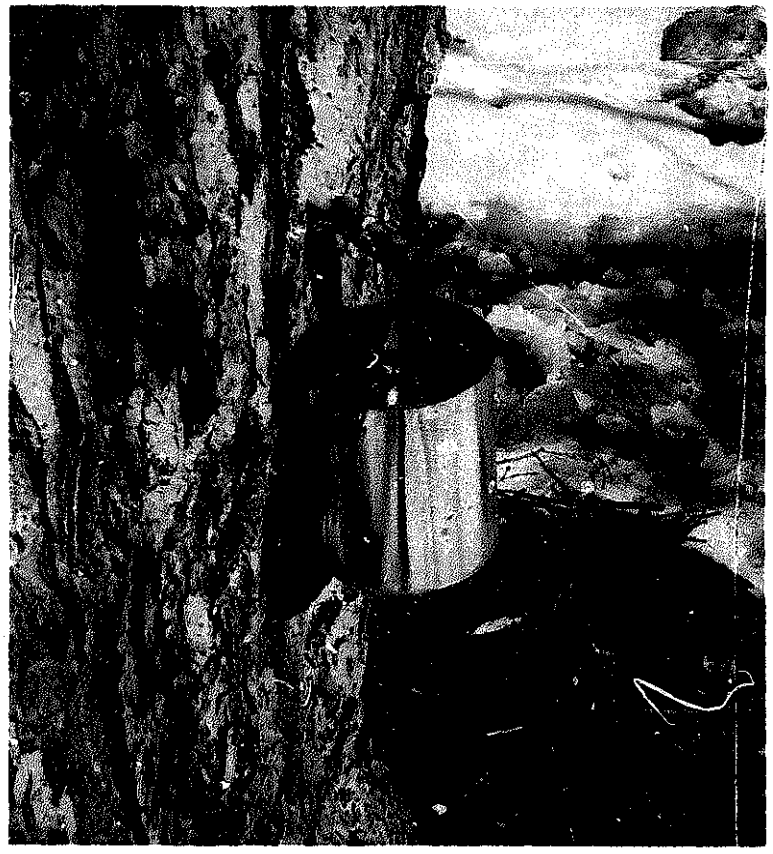
by Bruce Mays

Two years ago, my neighbor and I devised a system that yields three gallons of maple syrup every year from a total investment of under 12 dollars. If we can do it, anyone can. Boiling your own maple syrup is surprisingly easy. And when that syrup is free, boiled during the first hint of spring in your own backyard, you know you're living well.

Sugar sap is manufactured by maple leaves all summer long, then stored for the winter in the roots. The following year, that sugar supplies a ready-made energy reserve to the growing tree until new leaves are able to photosynthesize their own. During the first thaws of spring, the roots must move that sap through the trunk to the branches. Only if conditions are right, only if the sap is racing like an elevator between the roots and branches, can the tree be bled. Warm, sunny days draw the sap from the earth. Freezing nights pull it back down. That combination is essential; any other locks the sap motionless in one spot or another. In the South, or by late spring, there are no freezing nights that will gather the sap to the roots. But don't despair. If you live in sugar country and the season is right, there is no mistaking it. Morning ice will cover the bark, and by afternoon, the branches will sweat with glistening sap.

The first step in sugar production involves drilling holes through the bark. A general rule of thumb calls for the holes to be drilled no closer than one foot apart in a waist-high circumference around the trunk. Each year the holes should be shifted three inches to one side or the other, making sure no new holes are above or below the old. Since sap flows only through the newest growth directly beneath the bark, the holes should be angled upward no deeper than three inches toward the center of the tree. Tap primarily the southern face: sunlight coaxes a quicker flow. The standard drill bit is $\frac{7}{16}$ inch; hardware store taps are made with that size in mind.

A tap is nothing more than a stiff pipe plugged into the hole that funnels the sap out of the tree. Any tubular, soft piece of wood will do. My own yard abounds with one-inch diameter sumac trees. Once the branches have been cut into six-inch lengths, it is a simple matter to ram a red-hot straight iron through the spongy pith. All that remains is to whittle one end of the shaft to a taper and drive the tapered end into the tap hole like a bung into a barrel of wine. The sumac will swell with the first run of sap, sealing the tap tightly against each hole. Professional buckets are made of



The top shaft should be tapered at one end and driven into the tree at an angle. It is best to have a covered collection can.

galvanized steel, come complete with a hood to keep out unwanted rain and snow, are very handsome, and cost $4 each. For that price, I can empty ugly homemade buckets every time it rains or snows. A friend of my neighbor's gave him three dozen unused number ten tin cans—for free. Any large container will do, of course. The tin cans were simply the most convenient for us. I have seen plastic gallon milk jugs and unused paint-stirring cans used with great success. By punching a hole on each side near the top and looping a length of wire between them, we produced three dozen collecting buckets in less than an hour. And when we hung the buckets from our homemade taps, the fit was extraordinary. Forty-nine-cent taps stick out only about an inch from the bark; our homemade variety extends five inches from the trunk, far enough to direct sap into the very center of each bucket. By carving a small notch near the end of each tap, the collecting cans were safe from even the strongest breezes.

Our total investment so far was nothing. By the second week of March, our taps carried clear sap in a stream, filling each two-quart can within hours. And if you hate the thought of all that boiling, stop there—maple sap in place of water makes the most exquisite tea and coffee you've ever tasted.

If you do boil it, there are a few considerations to prepare for before you begin. If you have a job during the week, you will probably want to boil only on the weekends. That means storing your daily collections for at least six days. Twenty-gallon trash cans with plastic liners are about as large a storage container as you want to get and still be able to move them easily.

Now, however, you must keep the sap cold during the week. Left by itself, on a warm day, collected sap soon clouds to a bacterial soup. The easiest solution is to keep the trash cans in daylong shade. Each night, a skim of ice will form to protect the sap during the following day. And when warm weather still threatened to melt the ice and spoil the sap, we simply froze some fresh sap

overnight in milk cartons and floated the chunks of ice in the cans. As long as even a small ice cube remained until dark we knew we were safe.

After eight days of collecting we were ready to boil. Once again, we were in a potentially expensive situation. From every 40 gallons of sap, 39 gallons of water must be evaporated. That takes a tremendous amount of heat. The only realistic way for a home maple boiler to produce syrup is to cook the sap over an outdoor wood fire. Our three gallons of syrup demanded about two cords of wood.

Four years ago, I used an old ten-gallon lobster pot for the actual boiling. For someone with only a few maple trees, this is fine. But remember, it takes 40 gallons of sap to produce one gallon of syrup, and the evaporation rate of that excess water is a direct product of the size of the pot. Water will evaporate only from a surface in contact with the air; no amount of heat can alter that fundamental rule. Anyone planning to produce more than a pint of syrup in less than a lifetime of boiling will be forced to use a professional evaporator. We were, and now I know we were right.



From every 40 gallons of sap, 39 gallons of water must be boiled off. Three gallons of sap call for about two cords of wood.

Don't let the word professional scare you. It means simply a very large pan. The smallest of them, like ours, is about five feet long by three feet wide and ten inches deep. That is enough to hold 50 gallons of sap and presents an evaporating surface of 15 square feet—a twenty-fold improvement over my lobster pot. Fancier, more expensive evaporators have baffled compartments to route the finished syrup away from the new sap, inlet spigots and outlet faucets, and mysterious coils winding along the bottom. But beyond all that finery is still the simple physics of a larger evaporating surface. My neighbor found our small, used pan in a local newspaper for $10. Five dollars each, and we had made our last expenditure.

It remains only to get the fire underneath the pan. In our case, that meant piling used bricks in a three-sided structure 18 inches high, making sure that the edges of the evaporator pan would sit snugly on the inner brick wall. I suppose the bricks should be cross-stacked for maximum strength, but by the time we set the pan, leveled it out, poured in the sap, and stoked two cords of wood, our neat rectangle was something of a shambles anyway. The real trick is to concentrate as much of the heat uniformly onto the pan while still allowing enough air into the blaze to keep it burning hot. That meant removing a stray brick for ventilation here and there, sticking an old stove pipe from

the back end as a chimney, maybe sealing the gap between the evaporator and the bricks with mud. Generally, though, it meant just watching the fire at all times to balance its needs.

There are some things to be remembered during your boiling day. If the boil slows, the evaporation rate decreases. Too much heat in one spot tends to melt the solder holding the pan seams together. You have to work on the furnace a little to prevent those annoyances. We slanted a dug pit towards the rear of our rectangle and tried to keep most of the burning wood near the bottom. The heat then tends to climb up the slope towards the mouth of the furnace and disperse somewhat evenly across the bottom of the pan.

Be sure to add fresh sap steadily throughout the boiling. Too much cold sap all at one time will quench your good boil and slow the evaporation rate. Each time new sap is added, a scum will rise to the top. Skim these impurities from the broth with a slotted spoon.

Finally, the sap will taste distinctly mapley. Since our three gallons of syrup made a dangerously shallow layer in the pan, we found it prudent to remove the syrup from the fire when it was obviously brown and sticky-sweet, but still too thin for good syrup. This meant boiling the last few gallons in pots on the kitchen stove, but that way you can watch the syrup more carefully as it thickens. Books will tell you to dip in candy thermometers, or to measure the specific gravity and weigh the sugar content. At that point, the usual rolling boil is replaced by a kind of brown foam that sudses above the syrup. Syrup at just the right stage will cling to the spoon like thin taffy as it cools.

Your new syrup should be poured through muslin or felt at least once to pick up stray flecks of ash left by the fire. If you're planning to store the syrup for longer than a few months, be sure to fill each container right to the top while still hot and cap it immediately. When the syrup cools, it will hold the cap down with vacuum and never spoil. Pint or quart mason jars are perfect for this, but old bottles or food jars—anything with a sealing lid—can be used. If the syrup ever does cloud, simply boil it again and rebottle it. In a cool spot it should keep for years.

By the end of the day everyone is exhausted. Last year we began at six in the morning and were still sitting in a freezing drizzle at eleven o'clock that night. In between, a half ton of sap was poured by cupfuls into the steaming evaporator, the fire was tended, new sap was collected, and spare wood split.

And yet every winter I am restless for sugaring season. By late February, I swear I can smell the sweet air from other boilers. There is something very special about this first outdoor project of the year, something very satisfying about using your hands and brains to produce such an indecently delicious syrup.

NUT SHELLERS

GROUNDNUT DECORTICATORS

Groundnuts, peanuts for example, have fibrous cellulose shells which need to be removed prior to consumption. The task requires a rubbing-stripping action and a method for cleaning. Most hand-operated decorticators do not do this and so require a separate winnowing step.

SOURCES OF MANUAL DECORTICATING EQUIPMENT

Handy Groundnut Decorticator

Built from steel and cast iron, the Handy is simple to operate and easily transported. Nuts are placed in a receptacle and the operating handle moves forward and backward, rubbing the nuts against spiked rustlers and the shelling grid. Kernels are not separated from the shells after decortication with this device.

Harrap Wilkinson, Ltd.
5 North Phoebe Street
Salford M5 4EA, U.K.

R. Hunt and Company Groundnut Decorticator

The distance between the galvanized, heavy mesh screen and the rubbing bars on this unit can be adjusted to accommodate a variety of sizes of nuts. Four different sizes of screen are available for this hand-operated sheller.

R. Hunt & Co., Ltd.
Atlas Works, Earls Colne
Colchester, Essex CO6 2EP, U.K.

CeCoCo Model 300D Peanut Sheller

In this model, revolving beaters shell the peanuts, and kernels are separated from the shells by a screen and fan. Output is 40 to 50 kilograms per hour, and kernel breakage is 2 to 3 percent.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Groundnut Sheller

A hand-operated groundnut sheller is available from:

Ubungo Farm Implements
P.O. Box 2669
Dar Es Salaam, Tanzania

Hand-Operated Groundnut Decorticator

For more information write to:

Dandekar Brothers
Sangli
Maharashtra, India



Hindsons Treadle Power Groundnut Decorticator
M/s. Hindsons Pvt., Ltd.

Hindsons Groundnut Sheller

This is a foot-operated, portable device designed to quickly separate nuts from their shells. The balanced flywheel eases operation, and the blower separates shells from the nuts. Maximum output of the unit is 441 pounds per 8-hour day.

M/s. Hindsons Private, Ltd.
The Lower Mall
Patiala, India

SOURCES OF POWER-DRIVEN SHELLING MACHINERY

CeCoCo Peanut Sheller

In the CeCoCo sheller, threshed and cleaned peanuts are shelled by a revolving beater mechanism. After being run through the machine, unshelled and shelled peanuts are separated with a fan and screen. Unshelled nuts should go back in the implement until shelling is complete. Breakage of kernels is between 2 and 3 percent. Four model types are available using 1, 2, or 3 h.p. motors and with outputs of 120 to 420 kilograms per hour depending on the model.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

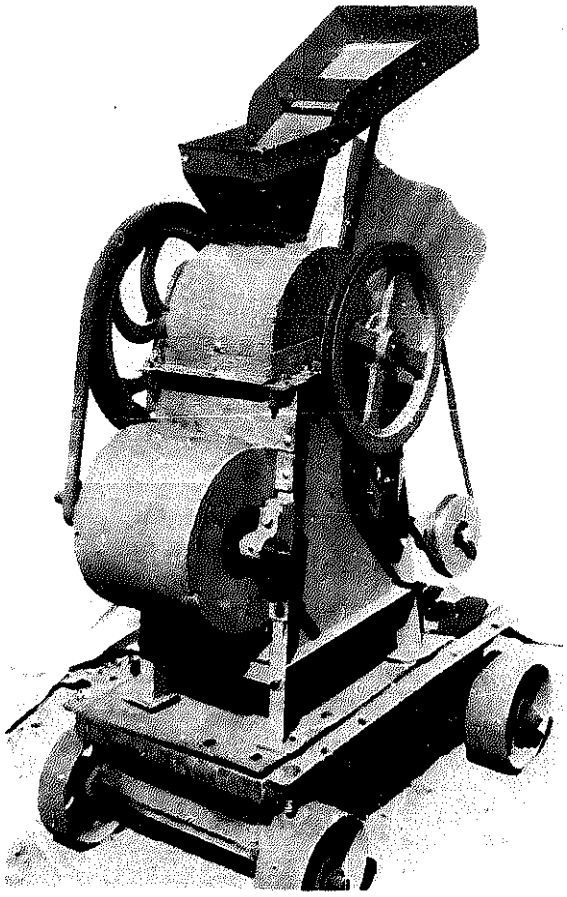
Harrap Wilkinson, Ltd. Automatic Groundnut Decorticator

Nuts to be shelled are placed in a hopper at the top of this machine. The nuts pass into a beater chamber by means of a ribbed feed roller; the rate is adjustable. Rotating, flexible beaters break the shells, and a blower mechanism separates the shells so that only the kernels are in the delivery chute. Wilkinson's No. 2 machine has a 1½ h.p. motor and an output of 254 to 406 kilograms per hour.

Harrap Wilkinson, Ltd.
North Phoebe St.
Salford M5 4EA, U.K.

Dandekar Brothers Groundnut Decorticator

Dandekar Brothers manufactures four types of power-driven decorticators. Type A needs a 5 h.p. motor and has an output of 80 (180 pound) bags per (12 hour) day. Type B requires a 6 h.p.



Dandekar Power Groundnut Decorticator
Dandekar Brothers

motor and will produce up to 100 bags a day. Type C is powered by a 7 h.p. motor and will shell up to 120 bags per day, and Type D uses a 10 h.p. motor for a maximum output of 200 bags per day. The hopper is on the upper part of the machine. Nuts pass from there into an opener cylinder where the shells are broken and separated from the kernels. The shelled nuts fall on the ground to be collected.

Dandekar Brothers
Sangli
Maharashtra, India

SINGLE NUT NUTCRACKERS

New Dynamic Nut Cracker

Designed to crack any size nuts except hickory nuts or hard-shell walnuts, this sheller locks and cracks them automatically. Kernels and shells fall out for rapid repeats, and the safety shield protects the operator from flying shell particles. This electrically operated device requires 110 volts and 60 cycle alternating current. The cracker is guaranteed for 1 year, and has an estimated life of 10,000 pounds of nuts.

L.H. Powell
8647 Wingate Drive
Dallas, TX 75209

Texas Native Inertia Nutcracker

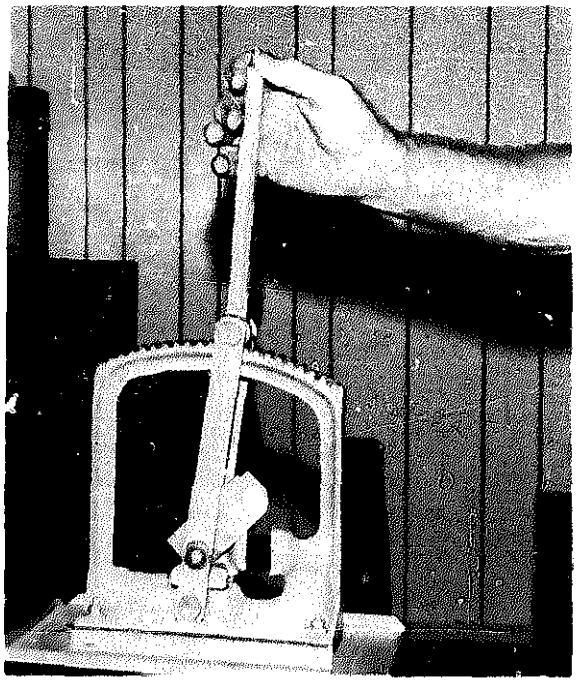
Made of oak and aluminum, this device will



Texas Inertia Nutcracker
R.P. Industries, Inc.

crack any type of pecan, Brazil nut, filbert, almond, macadamia, and English or California walnut. The cracker operates by placing the nut between two sockets, pulling the safety shield over the nut, pulling back the knocker stick, and releasing it. The kernel is left in the sockets, and the shell falls away from it. The tool is guaranteed for 1 year, and can crack up to 30 nuts in a minute.

R.P. Industries, Inc.
610 W. Johnson St., P.O. Drawer 10938
Raleigh, NC 27603



The Potter Walnut Cracker
Fred Klingensmith, Inc.

Potter Walnut Cracker

This device cracks walnuts one at a time. Heavy-duty crackers are also available.

Fred Klingensmith, Inc.
Sapulpa, OK 74066

RICE HULLING

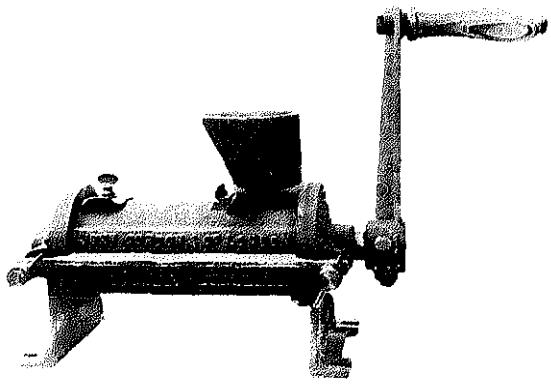
Similar to wheat, rice grows with a bran layer and an outer hull covering the kernel. For the grain to be edible, the hull must be removed in the hulling process. An unnecessary second step, polishing, removes the bran and the germ, and along with them, much of the grain's B-vitamin content. Rice that is hulled but unpolished is called brown rice. Both the hulling and polishing processes require a milling action, often by two rollers rubbing the kernel between them. Most hullers are designed for power operation, but a few hand-operated models are still being made.

SOURCES OF RICE HULLERS

Java Hand-Powered Rice Huller

This is a small machine intended for the grower of small quantities of rice paddy, and for domestic use. It replaces a model called the Paddy Pounder. Paddy can be shelled at a maximum rate of about 30 pounds (14 kilograms) an hour, but the capacity may vary considerably depending on the type of rice and its condition. The machine has three adjustments controlling the feed, the discharge, and the hulling knife. A perforated plate allows dust to escape, and the machine can be opened easily for cleaning. Strongly made, its net weight is 23 pounds (10.5 kilograms), and it is provided with holding-down screws and spanners.

John Gordon & Co. (Engineers, Ltd.)
196a High St.
Epping, Essex CM16 4AQ, U.K.

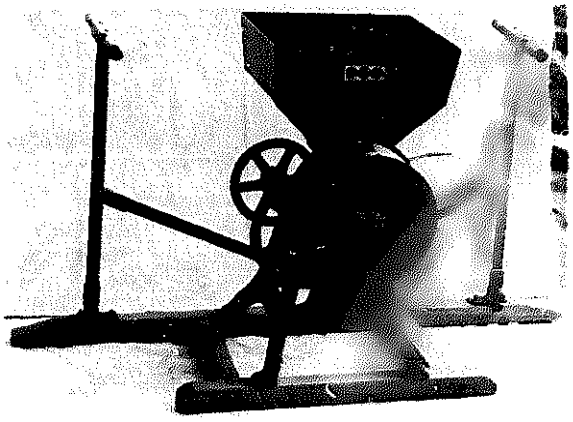


Java Hand-Powered Rice Huller
John Gordon

CeCoCo Two-Man Rice Huller

Two men operating the hand levers will rotate this huller at 3,500 to 4,000 rpm, hulling

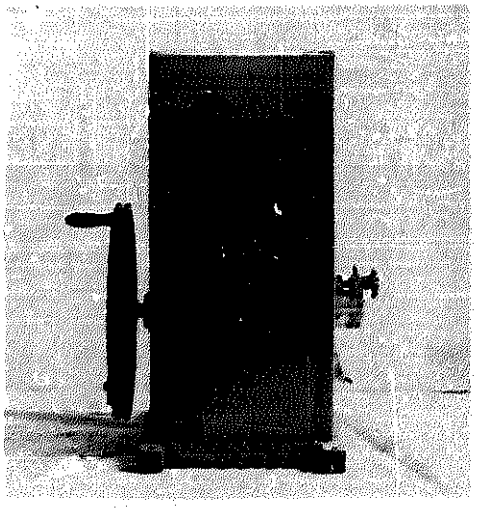
250 kilograms per hour with 90 percent hulling efficiency. Net weight: 60 kilograms.



CeCoCo Two-Man Rice Huller

CeCoCo Hand Rice Polisher Type E

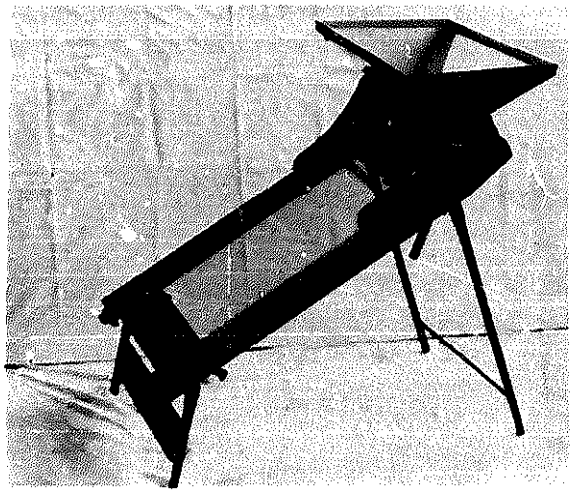
Operated either by hand or by a ¼ h.p. motor, the Type E Polisher will polish unhulled rice that has already been dried and winnowed. Capacity is 10 to 15 kilograms per hour by hand, and 30 kilograms with a motor. Weight: 22 kilograms.



CeCoCo Hand Rice Polisher Type E

CeCoCo Hand-Hulled Rice Separator and Sorter

Constructed of steel and easily dismantled for storage, the four models of this sorter have capacities ranging from 20 to 32 bushels per hour. Hulled rice is fed into a hopper, and while sliding across the surface of the piano-wire screen, it will separate into whole hulled rice, unhulled rice, unhulled paddy rice and immature rice, mud, and sand. It may also be used to sort polished rice for grading.



CeCoCo Hand-Hulled Rice Separator and Sorter

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

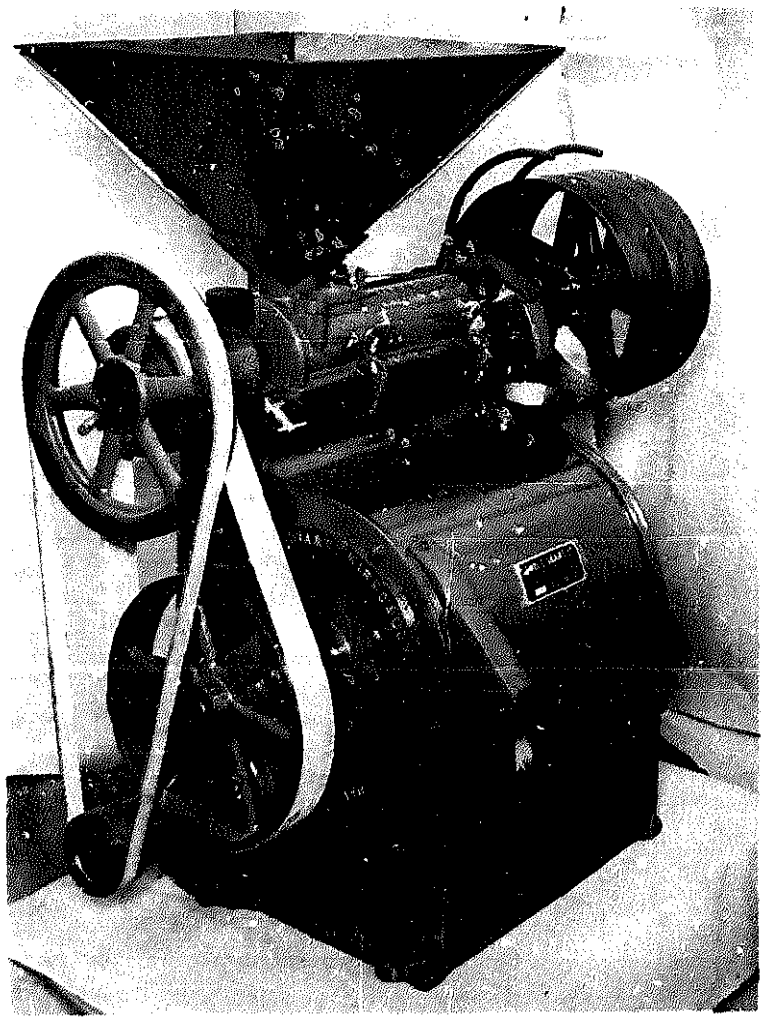
Amuda Rice Hullers

These power-driven machines can be used as hullers alone or supplied with polishing attachments. Three models are available, requiring 5, 12, or 15 h.p. They will hull rice from the paddy or shelled rice. From the paddy, the smallest huller will produce 36 to 45 pounds of cleaned rice; the middle, 136 to 204 pounds; the largest, 250 to 295 pounds per hour. When using shelled rice, production capacity is a little less than double those amounts per hour.

Rajan Trading Co.
P.O. Box 250
Madras 600 001, India

Grantex Rice Hullers

Three sizes of Grantex hullers are made. The smallest, requiring 5 h.p., produces 80 to 100 pounds of polished rice per hour. The amount is doubled if shelled rice is being polished. The two larger models utilize 12 and 15 h.p., respectively; they produce 300 to 450 and 500 to 650 pounds per hour. The two larger models can



Grantex Rice Huller
Lewis C. Grant, Ltd.

produce five separate products directly from the paddy: white rice, coarse meal, fine flour, bran, and husk. Optional extras include polishers, aspirators, fans, drive units, and reciprocating sieves.

Lewis C. Grant, Ltd.
East Quality St., Dysart
Kirkcaldy, Fife, KYI 2UA U.K.

Iseki Rice Polishers

The Iseki Model JE25 is an automatic, cabinet body machine. Horsepower required to operate the polisher is 4 to 5, and 300 to 350 kilograms of rice can be polished per hour. The manufacturers recommend combined use with a rice huller, but state that it can also be used as a rice-hulling and -polishing machine. Three larger models are available, either in cabinet or strip enclosures. Efficiency ranges from 300 to 1,000 kilograms per hour. None of the Iseki models include their own power units.

Iseki Agricultural Machinery Mfg. Co., Ltd.
1-3, Nihonbashi 2-chome, Chuo-ku
Tokyo, 103 Japan

CeCoCo Automatic Rice Hullers and Combinations

CeCoCo, with its wide variety of all types of machines, offers seven automatic rice processors, with many sizes of each type. Their automatic hullers feature rubber rollers, which they claim will increase output recovery of hulled rice 15 to 20 percent. They also recommend that rubber-rolled rice be stored and shipped as brown rice,

with any polishing to be done at the destination of the shipment to avoid deterioration of the product.

1. Rubber Roll Rice Huller: The original model consists of a hulling head and installation bed. Separation of brown rice and husks is necessary. Seven models are available, ultilizing 1 to 10 h.p. or V-belt drive; capacities range from 500 to 4,000 kilograms per hour in paddy.
2. Combination: Three models, with or without suction husk exhaust, are offered. The basic unit includes a huller and husk winnower. The suction exhaust model is recommended for use in buildings. The three sizes utilize from 2 to 5 h.p., with capacities ranging from 500 to 2,000 kilograms per hour.
3. Automatic KL-A: This self-contained unit includes hulling head, winnower, double elevator, separator, and rice elevator. The smaller model requires 4 to 5 h.p. and produces 600 to 700 kilograms per hour; the larger requires 5 to 6 h.p. and produces 1,000 to 1,200 kilograms per hour.
4. Automatic AM and ME: These are miniaturized versions of the complete unit, suitable for a single farmer or a group of farmers. The one-body construction includes huller, winnower, and separator.

Three larger rubber roller units, having hourly capacities of 1,200 to 4,000 kilograms, are also available.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Nogueira Rural Rice Mill

The Nogueira Rice Mill husks and polishes rice, then separates polished rice, husks, rice bran, and broken rice. It will utilize a 3 h.p. electric motor, a 6 to 9 h.p. gasoline motor or a 5 to 8 h.p. diesel-oil motor. Production capacity is approximately 2 sacks (60 kilos or 132 pounds) per hour. The cabinet is metal and weighs 236 kilograms.

CIMAG: Comercio e Industria de Maquinas Agricolas Ltda.
Rua Padre Roque no.° 1,840, Mogi-Mirim S.P.
Brazil

Genuine Engelberg Combined Rice Huller and Polisher Number 3

Powered by flat belt-drive pulley, this 3 h.p. machine will, in a single operation, hull, scour, and polish rice as it is received from the thresher. An optional built-on exhauster is available to carry away chaff and dust.

This item is suggested for small mill operators or larger growers. The No. 3 has a capacity of 80 to 100 pounds of rough rice per hour, and two larger models are capable of up to 700 pounds per hour.

Genuine Engleberg Huller Number 4

Similar in design to the No. 3 Rice Huller and Polisher, the No. 4 does not contain the polisher attachment. Two larger models of hullers are also available.

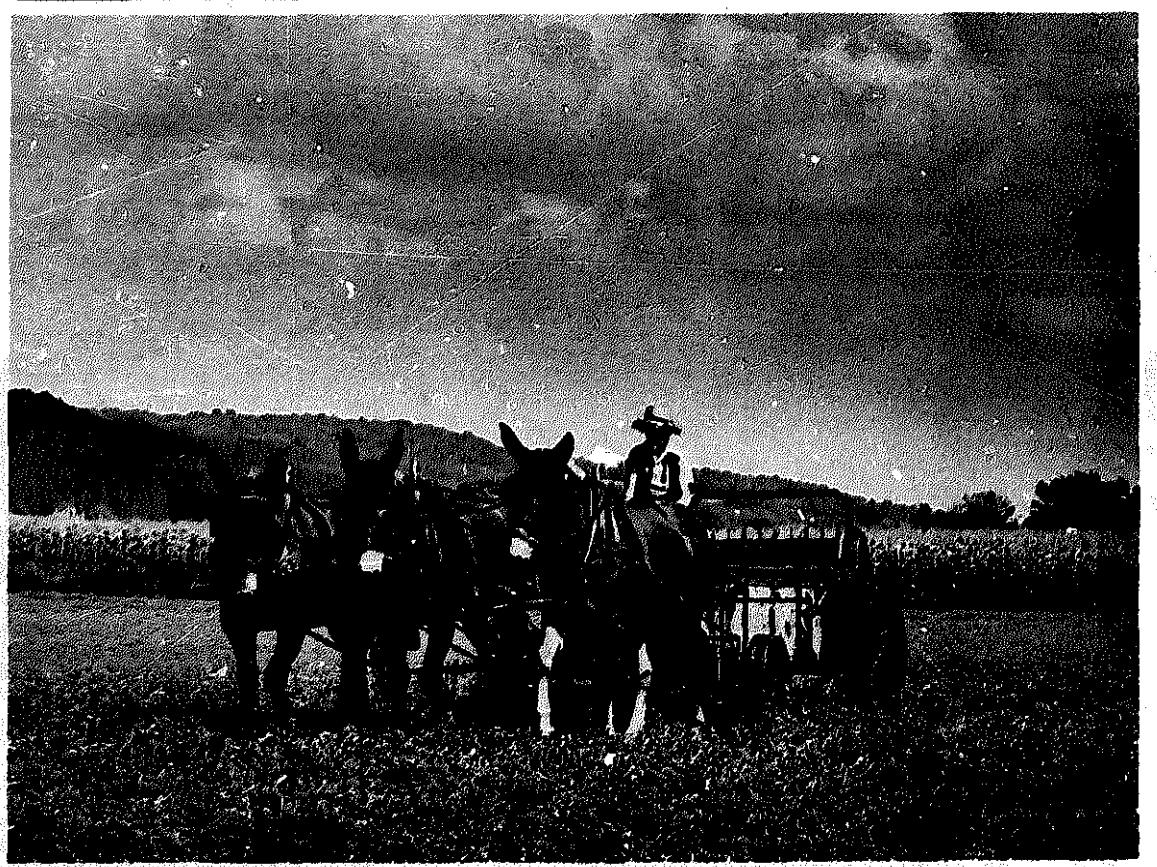
Engleberg Huller Co. Division
P.O. Box 277
Factoryville, PA 18419

-9- Tools for Adding Organic Matter to the Soil

To the practitioners of today's chemical agriculture, a fertilizer is a substance that has a measurable quantity of at least one of the major nutrients required by growing plants. The most widely used chemical fertilizers are those which contain three primary plant nutrients: nitrogen (N), phosphorus (P), and potassium (K) in varying combinations.

Organic growers, on the other hand, rely on natural fertilizers to maintain and replenish all the elements in their soil that are necessary to plant growth. They view soil fertility as a broader, more complex concept which involves not only specific plant nutrients, but also organic matter, the living organisms present in the soil, and the very structure of the soil itself. To them, humus content and tilth are important aspects of soil fertility. Unlike those farmers who employ chemical fertilizers to supply their crops with specific nutrients in forms that are readily available, organic farmers use a variety of natural materials to maintain and improve overall soil quality. In this way, soil fertility and health are improved even as crop yields increase.

Direct application of livestock manures has been the farmer's traditional approach to return-



Mule-Drawn Manure Spreader
Reading Eagle, Lancaster County, Pa.

ing organic materials to the soil. Originally, manure was spread over the soil surface from a cart, with a many-tined pitchfork called a manure fork. Then came the development of the manure spreader, a horse-drawn cart with a ground-driven set of chopping blades in the rear. Manure fed into the blades was chopped into small pieces and evenly distributed onto the field.

SOURCES OF MANURE SPREADERS

Most manure spreaders made today are designed for pulling behind large tractors beyond the scope of this book. They are easy to locate through most agricultural equipment dealers. Farm auctions are the best source for smaller units in North America.

Uebler Mini

One company to appear with a mini manure spreader, requiring only the power of an 8 to 12 h.p. tractor, is Uebler. Their smallest model has a capacity of 18 bushels which it distributes under power from its own 4 h.p. gasoline engine or a power take-off shaft. Their next size larger has a 50-bushel capacity.



Uebler Mini Manure Spreader
Uebler Manufacturing Co.

Uebler Mfg. Co.
Vernon, NY 13476

New Idea

The smallest manure spreaders put out by New Idea are a 138-bushel model with the combined chopping action of a cylinder and paddle, and a 146-bushel, single-beater model.

AVCO. New Idea Corp.,
Farm Equipment Div.
First & Sycamore
Coldwater, OH 45828

OrBilt Manure Spreader

The main beater of this spreader is made from heavy channel iron. These channels are welded around the beater pipe in two opposing spirals. This beater will tear apart the toughest manure, whether it is from a feedlot or pen, even if it is frozen. Strings don't catch or hang on this beater as they do on others. A lower-splash blade beater has the specific purpose of breaking up and scattering both liquid and clumps. This lower beater is particularly useful if you are spreading on a hay field or some other place where large lumps could smother patches of a crop.

The sliding pusher and false front endgate move as one unit to the rear of the box. The speed is controlled from the tractor seat by a variable flow, hydraulic valve. The pusher, replacing the traditional conveyer apron, is the heart of the entire machine. Part of the hydraulic cylinder is enclosed by the center housing



OrBilt Manure Spreader
O'Reilly Manufacturing

of the sliding pusher; the other part extends out over the tractor hitch. The entire inside of the box is lined with tough plastic. Manure does not penetrate or stick to the plastic, nor does it freeze to plastic as it does to wood or steel.

O'Reilly Manufacturing
Rt. 3
Goodhue, MN 55027

Prototype Material Spreader

Charles E. Fox, of Jonesboro, Louisiana, has invented a spreader wagon that hitches to a tractor and distributes material such as pulverized chicken fertilizer, sawdust, or ground bark. It is a two-wheeled cart with a series of arched platforms in its bed that funnel material onto a conveyor belt, and then through a gauging or measuring device. The gauge limits the amount of material laid per foot. The belt can be disconnected for transport. Mr. Fox is currently seeking a manufacturer for his spreader with the help and guidance of the Raymond Lee Organization. His invention, covered by a patent application pending in the United States Patent Office, is designed primarily for organic farmers.

Charles Fox
Rt. 3, Box 77
Jonesboro, LA 71251

Raymond Lee Organization, Inc.
230 Park Ave.
New York, NY 10017

COMPOSTING

Manure spreaders are still a necessary tool on the organic farm, but increasingly they are being used to spread composted manures and other organic wastes. Composting is the biological process of decomposition during which wastes are broken down into their basic chemical parts and made ready to be used again in building another plant. The product is called humus.

With the proper microorganisms present in the soil, humus will evolve by simply applying organic wastes to the soil surface. However, composting speeds the process, and by following a basic composting recipe, a more-balanced nutrient fertilizer is produced.

COMPOSTING AS A MANURE MANAGEMENT SYSTEM

by Richard Thompson

Editor's note: Richard Thompson was born and raised on his present farmstead, consisting of 300 acres outside Boone, Iowa. He graduated from Iowa State University with a B.S. in Animal Husbandry and an M.S. in Animal Production.

Composting, in my opinion, is a sensible, practical, economical way to deal with animal waste on the farm. My reasons for starting to compost followed the same pattern as my reasons for changing to organic farming back in 1967, namely—problems.

Back then I was on a continuous corn program, applying chemical N-P-K, herbicides, and insecticides. The fences were removed from between the fields, cattle were brought in and confined to barns and lots.

We live in a low, flat area so the barns and lots needed to be cemented. This situation brought about all kinds of sickness in the cattle. It seemed like it was just one thing after another. I got to the point where, out of frustration, I said, "There has to be something better than this." In the spring of 1968, we stopped using all chemicals and started putting fences back, so the cattle could have limited pasture. The cropping system was changed to a corn-soybean-corn-oats-hay rotation.

Even with all-chemical N-P-K added to the continuous corn program, I had to dispose of all the manure from the cattle and hogs. Note that I say dispose of, not use. The manure was hauled out of sheds and lots during the winter and early spring, and applied to frozen, plowed fields that were often covered with snow. This was a very poor utilization of the nutrients, especially the nitrogen content in manure which would turn into ammonia, dissipate in the air, and be completely lost. Also the raw manure would move with the melted snow and end up in creeks and rivers, polluting our water supply.

After I stopped using the artificial N-P-K, the corn yields stayed at 120 bushels per acre for the next seven years. The corn yields, previously, were about the same, averaging 120 bushels per acre.

My yields, on the organic program, were oats: 70 to 80 bushels, soybeans: 35 to 45 bushels which, I felt, were good and also competitive with the neighbors. The hay fields also seemed to improve each year. After about seven years of organic farming, the field of corn following soybeans dropped to the 80- to 90-bushel range. The cornfield following hay remained in the 120-bushel range. The profit on the 80- to 90-bushel yield would probably be okay, since the expenses per acre were $40 to $50 lower than those of the neighbors on chemical methods. However, I felt with all this manure and only 80 to 90 bushels, something must be wrong. This was where composting came into the picture.

Composting is a way of turning a liability into an asset on the farm.

In the spring of 1975, we decided not to spread the manure on frozen ground during the winter. The manure was pushed up into large piles in the yards during the winter. On June 5, we started to clean out these piles and haul to our compost site on the edge of the hay field. This manure was cold and had large chunks of ice in it.

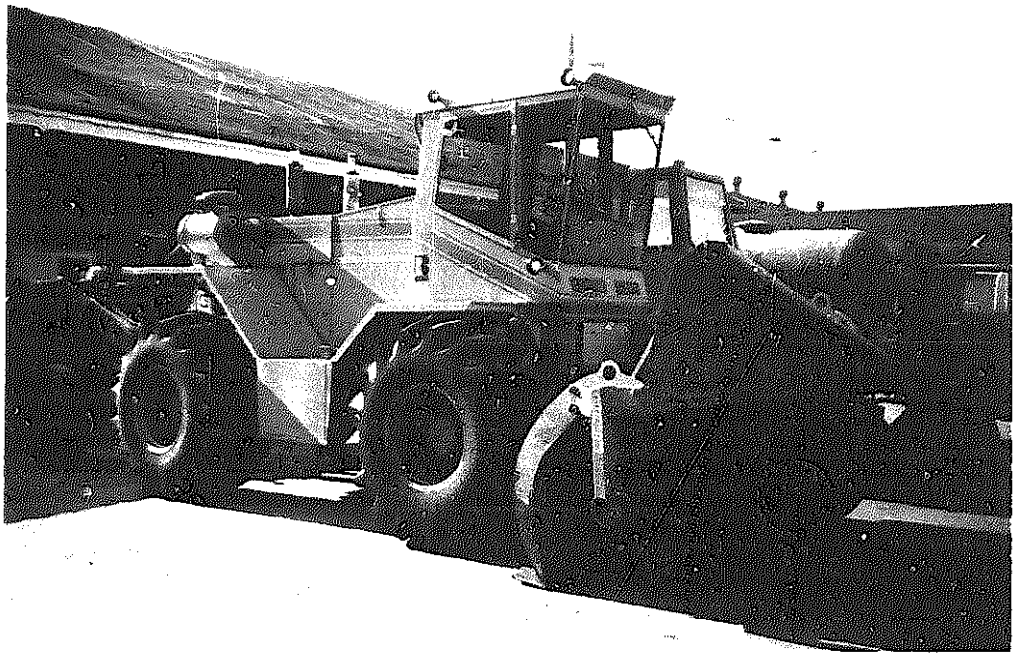
A bacteria starter was spread on the manure piles in the yard, loaded in the spreader, and taken to the compost site located centrally between our farmstead and the neighbors'.

The spreader needs to be power take-off-operated so it will unload in a stationary position. When the manure builds up to the beaters, the spreader is moved forward about one foot and the rest of the load is unloaded in this fashion. I feel the ideal pile is about eight feet wide at the bottom and four feet high. In two days' time we saw a miracle happen. This cold, frozen manure which had a temperature of about 30 to 40 degrees heated up to 140 degrees, and steam was coming out of the top of the windrows. I feel that, in my situation with all the manure off concrete, I need the added bacteria to get the action started, as little earth was combined with the manure. We tried some windrows without bacteria and the action was very slow.

One of the important keys to good composting is moisture content. This should be in the 40 to 60 percent range. If the manure is wetter than 60 percent, it will take more turnings with the spreader to get it dried down. If the manure is too dry, water needs to be added. Generally, I take some wet manure and mix it with dry manure and this usually comes out about right. Much has been written about carbon-nitrogen ratios in composting; they should be 20 to 30 parts carbon to one part nitrogen. For the farmer, I think this means simply that what creates a good environment for livestock will make good compost. If cattle or hogs are kept clean and dry with bedding, the carbon-nitrogen ratio will be excellent.

My windrows were turned by reloading the spreader and unloading to make a parallel windrow. The windrows need to be turned until the temperature stays below 100 degrees. However, if it is time to spread on fields, incomplete compost that is still steaming can be applied to fields and disked in the same day. We initially applied four tons of compost per acre in fall after the soybeans were combined and bean straw was stacked. The N-P-K analysis of the compost was 2-1-2.

This year I bought an Easy Over compost-turning attachment for my tractor. With this attachment



The Brown Bear Integral Auger Tractor



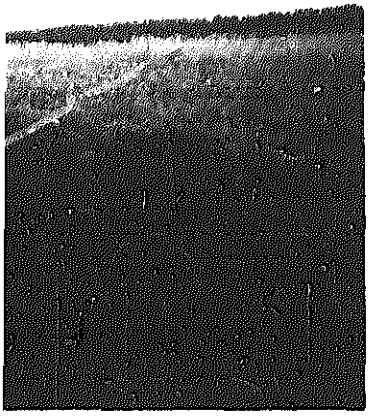
Feedlot manure and crop residues are composted with the aid of the Brown Bear turning machine at the University of Nebraska's Mead Field Station.

including a gearbox, tool bar, and silage-unloading auger. The auger is used to aerate, break up, and mix the pile. Afterwards, a tractor loader is used to repile the materials.

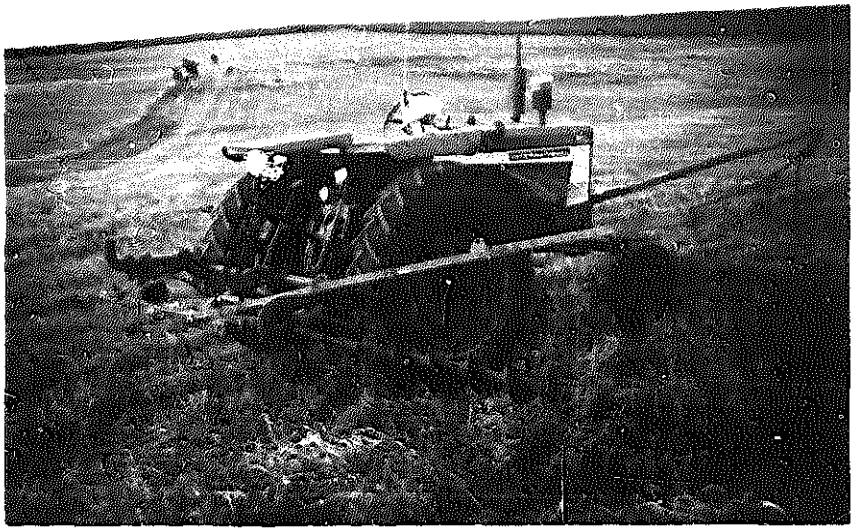
Wuebben has been keeping daily records of the temperatures within the compost at 50 different points along his 500-foot windrow. The records have indicated that the temperatures of the pile rose substantially after each turning and also following rains that occurred between turnings. The increase in temperature following a rain would indicate that the moisture content of the compost wasn't adequate for optimum bacterial activity.



Edgar Wuebben's home-built compost turner.



atory to be analyzed with the



Edgar Wuebben's home-built compost turner.



Wuebben's compost turner in action.

A sample of the finished compost was taken to an Omaha laboratory to be analyzed with the *following results:*

Moisture	34.80%
Nitrogen (N)	0.80%
Phosphorous (P_2O_5)	0.62%
Potassium (K_2O)	1.17%
Organic Matter by Combustion	14.40%
pH	7.3
Total Organic Carbon	8.5 %
Carbon-Nitrogen Ratio	10.6

A tractor-powered, turning machine built by the Mehlaf Machine and Manufacturing Company of Freeman, South Dakota is used to turn compost at the rate of 400 to 500 tons per hour. This unit is used by Town and Country Park, Inc., in Sioux Falls, South Dakota, which processes sewage sludge, paunch manure, and stockyard pen wastes.

At the McGinley-Schilz feedlot in Brule, Nebraska, a specially designed machine aerates the windrowed manure. The compost is made under contract with the Colorado-Nebraska Compost Corporation owned by Jack E. Martin and Lester R. Kuhlman of Sterling, Colorado. The machine, known as the Scarab, was developed by Fletcher Sims of Canyon, Texas.

"About 20 tons of raw manure to the the acre would have to be applied to equal the benefits derived from two tons of compost," says Martin.

"It's turned our feedlot waste problem around. Instead of manure being a nuisance, it's a valuable asset," Schliz was quoted in an *Omaha World-Herald* article.

SOURCES OF COMPOSTING EQUIPMENT

The Cobey Composter

An Ohio feedlot has effectively used the Cobey Composter for processing animal wastes. This unit is a diesel-powered, self-propelled machine which straddles the windrows.

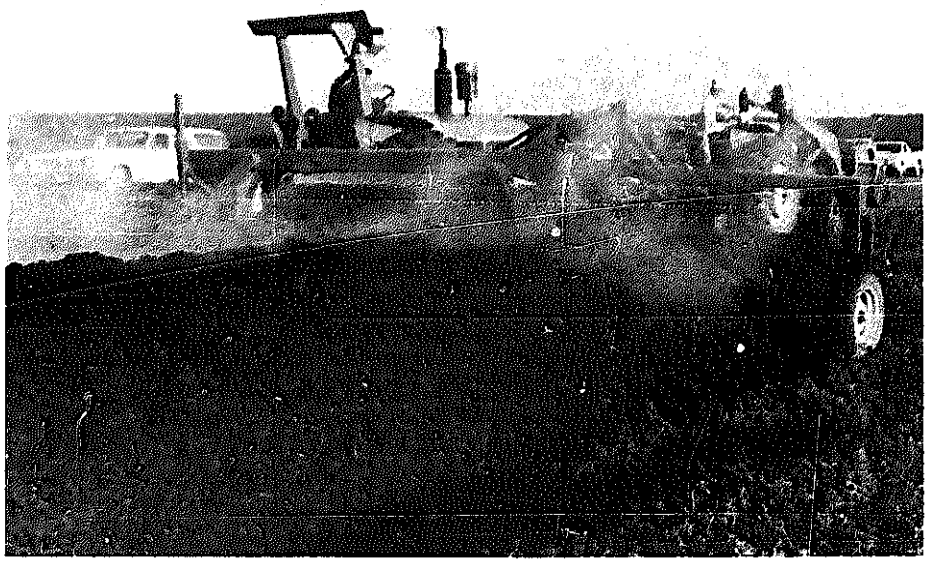
Manufactured by:
Eagle Crusher Co., Inc.
Rt. 2, Box 72
Galion, OH 44833

The Easy Over Composter

Another composting machine was developed by the late Elton Schaeffer of Menno, South Dakota "out of his own necessity." The machine has knives similar to those of a garden tiller, for lifting material up and back into the windrow. One-half of a compost windrow is taken with each pass of the machine, compared to the full windrow taken by larger machines. The operation, according to Schaeffer, is best accomplished with a hydrostatic-drive tractor for slower ground speed.

Schaeffer's machine now has the commercial name of Easy Over, and is distributed by:

General Corp.
322 S. 16th St.
Philadelphia, PA 19102



The compost turning machine used on the Elton Schaeffer farm at Menno, S.D., for composting manures brought to the farm from the local livestock sales barn.



Schaeffer's composting machine has tines similar to those of a garden tiller, to lift material up and back into the windrow.

Accelerator Compost Bin

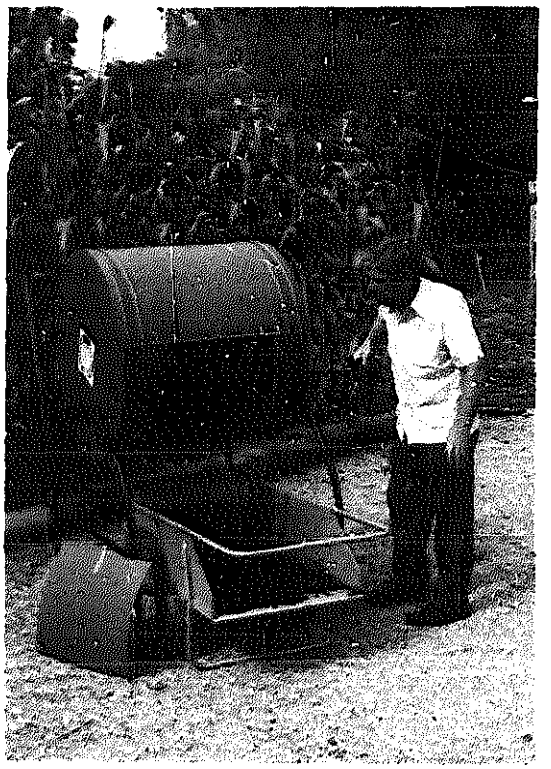
This 34 by 36 inch circular bin is made up of green, rigid, polyvinyl chloride interlocking and sliding panels. Waste is added through the top of the bin which has an inflatable cover to repel rain. Ventilating holes in the panels allow for ventilation while helping to hold in heat and insulate.

Rotocrop (U.S.A.) Inc.
P.O. Box 237, 58 Buttonwood St.
New Hope, PA 18938

Farnam
Dept. HB957, P.O. Box 12068
Omaha, NE 68112



Rotocrop Accelerator
Rotocrop (U.S.A.), Inc.



Compostumbler
Gardening Naturally

The Earthmaker and Compostumbler

This compost bin is arranged on a stand which allows the drum to be rolled in place. It holds more than 14 bushels of raw, organic waste and retains liquids.

Gardening Naturally
Rt. 102
Stockbridge, MA 012[illegible]

Garden Way Mfg. Co., Inc.
102nd St. & Ninth Ave.
Troy, NY 12180

Global Services, Inc.
P.O. Box 185-A, College Park
Lewisburg, PA 17837

Hand-Operated Mini-Composter

The steel blades of this composter grind vegetable refuse, bush clippings, vines, roots, and weeds up to a ⅜ inch diameter. Measuring 15 by 10½ by 8 inches, it clamps to any flat surface. The cast-iron cutter is manually operated.

Sears, Roebuck & Co.
Farm and Ranch Catalog

Cassaplanta
Dept. 123, 16129 Runnymede
VanNuys, CA 91406

SHREDDERS

Today's shredder-grinders are better than they've ever been—thanks largely to 20 years of organic gardening experience contributed and shared by a multitude of backyard growers. They're also more available in greater variety—some larger and more powerful, and some more compact—but all are designed to do a specific gardening job better.

The type of shredder you buy should depend on the kind of gardening operation you run, the size of your place, and the kind of organic materials you're going to feed through it. A good shredder will handle all kinds of garden wastes and residues without clogging, and it should be easy to move around, which means you can take the tool to the work—to the compost pile, the garden row, or the pile of wood chips that were dumped at the end of your driveway.

Today, there are two main types of shredders: the low center of gravity shredder-bagger with its big-mouth hopper, and the classic stand-up shredder-grinder designed to handle a greater volume and variety of materials.

Many combinations of accessories and functions are now available in one machine. The once-reluctant gas engine has been made a lot more dependable and easier to start. You can also find electric-powered shredders which are a lot quieter, easier to start, and also free of fumes. But they have to stay closer to the house and there is always the danger of playing around with electricity outdoors on the damp ground.

Many shredders, both low-profile baggers and the bigger grinders, are equipped with a chipping fixture which is usually a rotating knife that operates through a side slot and can



To keep a shredder from clogging, it's sometimes best to remove the screen, especially when shredding wet, soggy leaves.

handle branches up to two or even three inches thick. The MacKissic, Roto-Hoe and Lindig machines are three models with this feature.

Then there are the shredder accessories or attachments that fit onto a small riding tractor or a walking power unit that also functions as a rotary tiller, a mower, a chipper, a snowblower, or even a dozer blade.

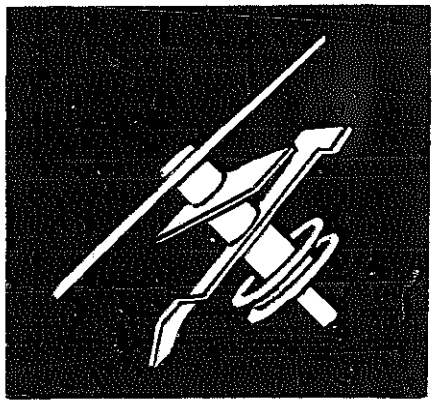
Overloading any machine will result in jamming and stalling it. This especially holds true for the shredder whose job it is to chop up fibrous, damp, or wet materials and then eject them through a screen or grid. We recommend working with as large a screen as possible—the 1¾ inch screen on the Lindig is excellent. Gilson, W-W, and Roto-Hoe offer a grating of rods or square roller bars which seem almost jam-proof. Another solution to the problem is the Winona's "wet mat rack" which encloses only half the shredding chamber.

If you're shredding with very wet, soggy, and rubbery leaves, here's a sure way to eliminate frustration and loss of time—remove the screen. Without it, the action of the cutters chops the leaves into a satisfactory aggregate which can be used either for compost or mulch. If you're working with a shredder-bagger, you may find it speeds up the task to remove the bag. You'll also find it's a good idea to deposit the aggregate immediately in the compost pile or the planting row.

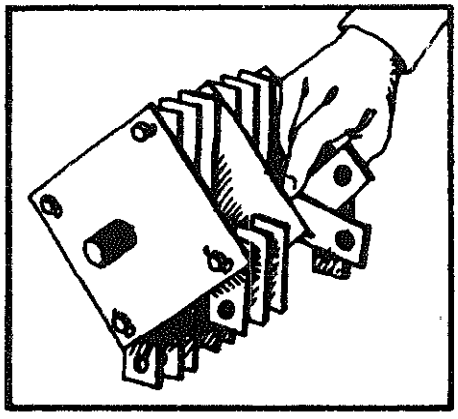
You may also find that a clutch, either centrifugal which depends upon the speed of the motor to actuate it, or one that is manually operated, helps avoid jams. This calls for alert operation of the machine, but it can save a lot of time spent clearing out the inside of your shredder.

Check the wheels on the shredders you are considering. They should have at least a pair, rugged and rubber-tired, and placed so they will comfortably and safely support the machine when you move it. Some of the larger models

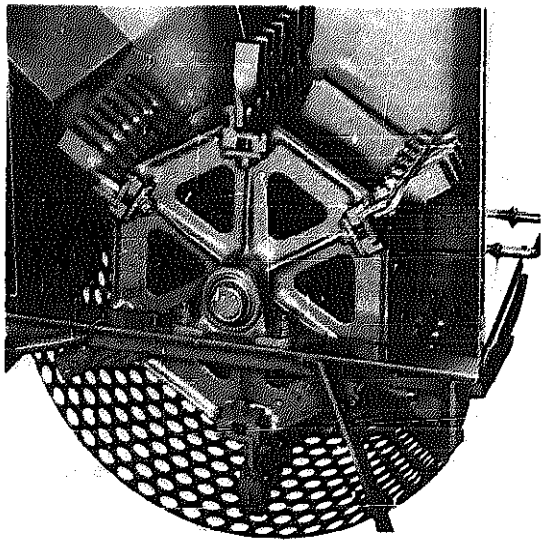
FOUR TYPES OF CUTTING MECHANISMS



Three-Cutter Rotary System

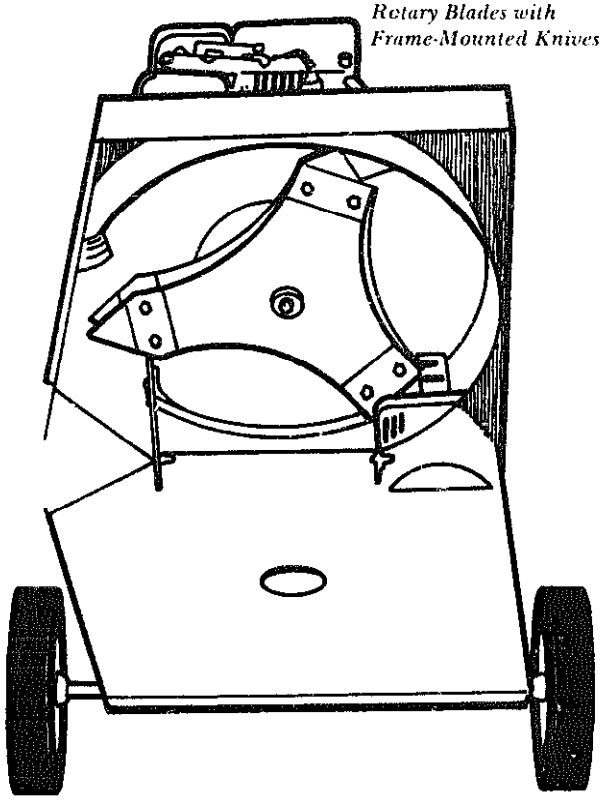


Hammer mill Unit



Rigidly Mounted Knives on Horizontal Shaft

Rotary Blades with Frame-Mounted Knives



Rotary blades that whirl through stationary knives mounted on the frame chop and fling the mass of particles out the side vent.

Another time-tested system is a series of knives rigidly mounted in a revolving horizontal shaft. The fabble plates and a screen tend to hold the material against the cutting action of the blades.

come with three wheels, and some with four. Make sure the machine you are thinking of buying handles easily and comfortably.

One of the most sensible gardening arrangements we've ever seen was at the Golden Acres Farm in lower Bucks County, Pennsylvania, where a double track of sturdy rails was erected over and along a series of compost bins. A king-sized shredder was mounted on the rails and traveled from bin to bin, depositing its aggregate as it went.

There are three or four basic systems for reducing and mixing your organic wastes. Hammer mill tempered steel flails revolve freely on a rotating shaft, and so have the ability to absorb shocks from hitting stones. There also seems to be a minimum of blockage in the mixing chamber caused by wet materials. Sets of hardened steel teeth or knives, fixed rigidly on a revolving shaft, work in combination with interior baffle plates and the bottom screen, which tend to keep the material in contact with the knives. The smaller shredder-bagger machines work with a series of two or three rotary blades similar to a lawn mower's. In some models, these whirling knives pass between stationary cutters that are part of the frame or chassis to achieve more complete cutting. The turbulence created by the rotary blades also whirls the aggregate out through the vent, which permits you to deposit it right where it is needed—either in the compost pile or in the planting row.

Any matter that is organic and compostable can be reduced to a workable aggregate or mass in your shredder. You will find that there is plenty of material on your home grounds to keep your shredder and you busy for a series of weekends, particularly in the late summer and fall. There are the weeds, the grass clippings, the crop residues, and the leaves. Add to these local benefits the contents of your garbage pail; it combines well with just about anything.

Next, there are the wood chips from the local road department, sawdust from the neighborhood lumberyard, and corncobs from the nearest feedmill (if you can get them ground). All of these varieties of cellulose are fine for mixing with the garbage. Working with unground corn cobs, though, can be tricky. The tough cobs have a habit of flying back up out of the hopper, right at your head. Some gardeners have reported that a thorough soaking (up to a week) of the cobs softens them and makes shredding easier.

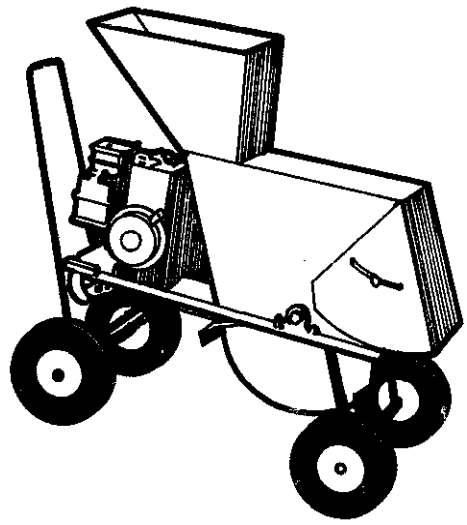
No garden chore is easier or pleasanter than shredding dry, autumn leaves. But if your leaves have wintered over and are tough, wet, and rubbery, feed them into the shredder in very small handfulls which are followed by dry sawdust, and again, be prepared to work without a screen.

TYPES OF SHREDDERS AVAILABLE

Think over your shredding needs carefully before you begin to shop for a machine. There are many different shredders on the market today, and rather than trying to list them all, we've decided to describe the basic types available and give some examples of each type. Keep in mind that models change from year to year, and be sure to investigate all the features of the models you're considering.

Large Shredder-Grinders

Most of the shredders in this group comprise the classics of the industry—the Amerind-MacKissic, Gilson, Lindig, and W-W. To them should be added the Royer, the Ariens, the Roto-Hoe, the Hahn-Eclipse and the Winona, all of which feature the larger machine in their wide-ranging lines.



Four-Wheel Shredder-Grinder

In general, these shredder-grinders are designed for the 1- to 5-acre place in the country, although you may be perfectly happy with one of these bigger machines on your suburban ½ acre. You'll find that they can handle a greater diversity of materials than the shredder-baggers and also a greater volume. And, thanks to their rugged framework and wheels, it's a lot easier than you would think to roll them out into the garden or up to the compost pile. It's also good to be able to report that shredders last for years with very minor repairs (made easily by the local dealer), so their cost can be amortized over quite a period.

Ameriud-MacKissic Model 12-P is a 6 h.p. combination log chipper and shredder-grinder. In addition to handling conventional organic composting materials including corncobs, it reduces logs up to 3 inches to wood chips. Model 9-P is powered by a 4 or 5 h.p. engine and works through a series of 24 free-swinging knives. Power take-off units are available for many popular small estate tractors.

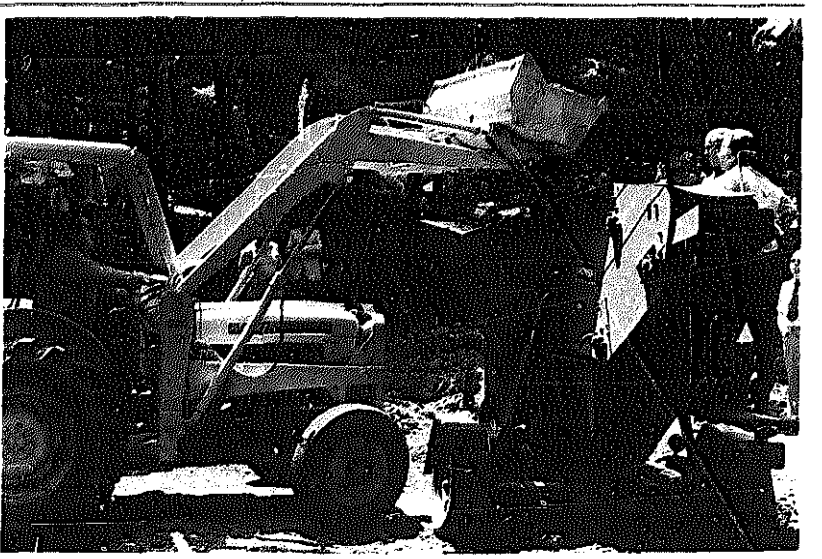
The 6 h.p. Gilson Chopper features nine, square, rotating cutter bars instead of a screen, which are ideal when you're grinding wet, soggy, fibrous materials. Cutting action comes from three sets of rotating double-edged knives—12 cutting surfaces. The gravity-feed hopper is king-sized—almost 17 by 17. The Chopper is belt-driven with an idler clutch.

The Lindig Concho is also available with an electric motor or a 5 or 7 h.p. engine. It offers a wide range of grinding screens from ¼ inch to 1¾ inch. A side-vented brush and wood chopper feed directly into the mixing chamber. The cutting and shredding unit is a series of free-swinging hammers. The steel frame is supported by three wheels, one up front which pivots plus two in the rear.

The 8 h.p. Roto-Hoe Cut'n Shred heavy-duty shredder-mulcher includes a side-feed which leads directly to three knives passing by a hardened block. We have used this feature to shred long, tough corn stalks, and found it did a good job. Built of 12-gauge steel, the frame sits on four wheels and has a long tow handle for easy mobility. The steel bar grate is wide-spaced to reduce jamming.

The Royer 8 is a specially designed machine whose endless shredding belt is lined with tempered steel cleats mounted in rows. Models 8, 10, and 12 are electric or gas powered with a capacity that ranges from 5 to 12 cubic yards per hour of soil, peat, and other organic materials. Many municipalities use the larger models for shredding prior to composting them. This is a well-made machine designed for blending, potting, and soil compost mixes.

In addition to a conventional screen, the W-W Model 62-G offers a grating of six rods and rollers for use when shredding wet materials.



The Royer Shredder

Powered by a 5 h.p. engine, it works through a series of tempered, hammer mill flails and can handle all conventional organic materials up to 1½ inch tree trimmings, small bones, phosphate rock, tin cans, and bottles. Optional grinding screens handle corn, wheat, or milo.

The Winona Model JR-AW comes mounted on four wheels, but Model JR-S can be mounted on a garden tractor or over the compost pit. The Winonas are electric or gas driven and have changeable racks including a wet mat rack for gummy materials which is a short screen covering only half the mixing chamber. Powered by a 2 h.p. engine, it works through a cutting unit comprising 16 hinged knives.

Lickity Chipster

The Chipster has an 8 h.p. gasoline-powered feed roll, a clutch to disengage the feed roll, a hammer mill-type rotor, shredding screen, and chip direction head. There are two wheels for convenience in moving, but the Chipster is not to be hauled as a trailer. The brush feed chute is 16 inches wide and 13 inches long with an opening to the rotor that permits feeding branches up to 2 inches in diameter. The self-feeding roller, located at the end of the chute, feeds the branch into the hammer mill-type rotor where it is shredded, screened, and dropped on the ground in front of the Chipster. If the dynamically balanced, hammer mill rotor should become overloaded, the powered feed roll will automatically stop until the overload has been cleared and then will automatically start again. Weight: 215 pounds.

Lickity Chipper Model PTO-5

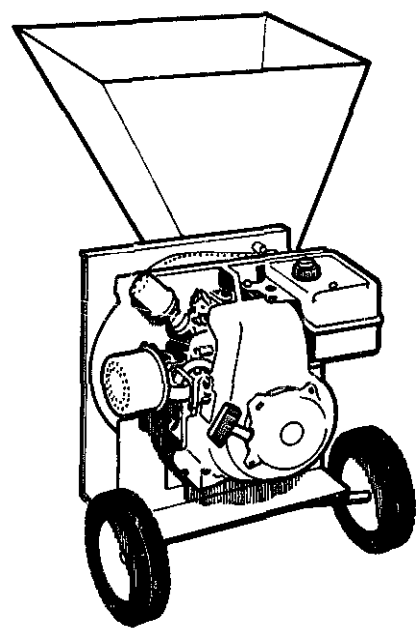
The Brush Chipper utilizes the power take-off of a tractor. The PTO model is equipped with wheels, tires, and tubes as standard equipment. It can be towed to the job at normal highway speeds behind any vehicle. The feed chute can be folded up and the blower discharge chute adjusted to make towing easier. The PTO model is equipped with a pin-type hitch coupler. The hammer mill rotor handles limbs up to 5 inches in diameter at a rate of 50 feet per minute.

A.M. Leonard & Son, Inc.
P.O. Box 816
Piqua, OH 45356

Diadem Brush Chipper

The Diadem Chipper will handle up to 3 inch diameter limbs. Brush self-feeds through the chipper and is converted into small chips in just a few seconds. Small brush can be processed in bundles at a time. It is constructed of heavy-duty plate steel with a 6 gauge (5 mm.) engine deck and a solid cylinder rotor. Imbedded in the solid rotor are two 0.4 inch thick cutting knives of specially hardened chrome vanadium steel. The wheeled Diadem is 30 inches wide; it can be taken anywhere for on-the-job brush disposal. All tires are fully pneumatic. You can choose from a three-point hitch PTO and 8, 10, and 12 h.p. models.

Vandermolen Corp.
119 Dorsa Ave.
Livingston, NJ 07039



Top-Vented Shredder-Bagger

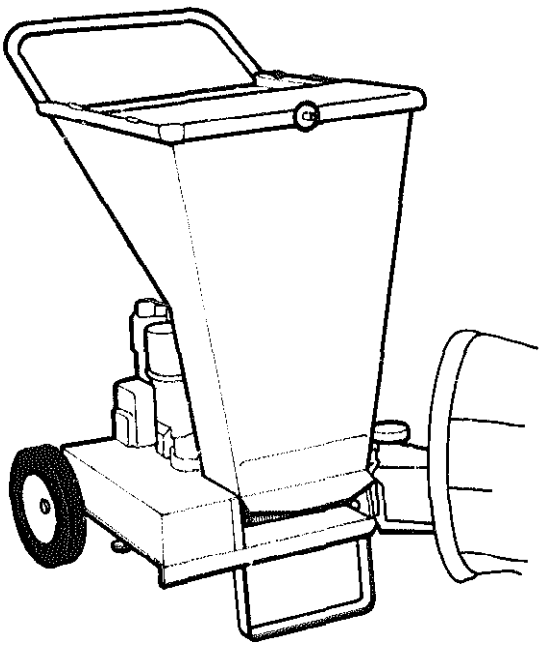
Top-Vented Shredder-Baggers

A top-vented, compact shredder-bagger will throw a stream of chopped aggregate into the garden or compost pile. The Hahn 3½ h.p. Mighty Compact and International Harvester 35P are in many ways identical. They are low-

profile, with wide-mouth, gravity-feed hoppers and a pair of wide-set, rubber-tired wheels for extra stability plus mobility. Both models feature hammer mill cutters and optional baggers.

Free-swinging, hardened steel hammers, a large feed hopper, and an adjustable discharge chute are built into the low center of gravity-feed McDonough Snapper. Model 30-S has been designed to handle leaves, bush trimmings, tree prunings up to ½ inch thick, and cornstalks. It is powered by a 3 h.p. engine with centrifugal clutch and belt drive.

A large (22 inches wide) drop chute for raking in leaves and other lawn debris plus a side-mounted chipping opening for branches are features of three top-vented shredder-baggers that are almost identical in design. They are the Columbia Model 654-4, the Jacobsen No. 50080, and the MTD No. 244-650. Powered by a 5 h.p. engine, each machine features a three-stage cutting action consisting of a single, flat reversible blade, nine flail knives, and four cutting fingers. In addition to the novel drop chute, these shredders each have extra-wide hoppers.



Bottom-Vented Shredder-Bagger

Bottom-Vented Shredder-Baggers

The Atlas, Cross, Kees, Roper, and Sensation models, while more or less identical in appearance—wide, low-set hoppers, each with a set of sturdy wheels, and engines mounted directly over the cutting units—are somewhat different in the features they offer.

The 5 h.p. Atlas does its cutting with three steel blades plus eight shear bars which permit it to cut wood up to 1 inch thick. Blade drive is direct from the engine. A poker rod has been built into the hopper for breaking up twigs and vines.

Cross shredders come in two models, the 3½ h.p. 4365, and the 5 h.p. 4650. Both shredders deposit chopped material in a bag and feature a sweep-in hopper that makes lawn cleanup easy. Power goes direct from the engines into the double-bladed rotary cutters.

The Kees Kom-Pak also has a rake-in hopper, an optional extra. Its steel cutting blades will handle wood up to 1 inch on the 5 h.p. model or ¾ inch for the 3½ h.p. Three bags are packed with each machine.

The 3½ h.p. Roper works with two high-speed blades to chop up leaves, twigs, and vines. It is worth noting that the accompanying Roper photos show it handling corncobs. The 6 h.p. model depends on triple cutting blades plus breaker bars in the chopping chamber. There is a fixed steel deflector on the discharge chute for directional control of the shredded matter. Bags are also available.

Power in the Sensation Eager Beaver goes directly from the engine to the double set of reversible blades without belts or chains; a safety clutch has been designed to protect the engine against shocks. The Eager Beaver dismantles easily for transport by car, thanks to large-diameter hand knobs.

The Sears 8 h.p. Super-Shredder resembles a rotary mower with its engine mounted directly over the three high-speed cutting blades. Shredded particles—leaves, vines, twigs, and garden debris—are vented at the bottom in a bag. The wide-mouthed but shallow hopper may be lowered for raking and sweeping in of lawn debris. Five bags are included.

The Toro comes in two models, 3½ and 5 h.p. Each features a big, slanting, gravity-feed

hopper with a pusher rod to handle the material. The engine sits directly over the cutter blades--two in the smaller model and three in the larger—which work in conjunction with the shredding bars at the bottom vent. An optional bagging kit is available.

SOURCES OF SHREDDERS

The following companies all market several different models of shredding machines:

Allis-Chalmers
Outdoors Leisure Products Div.
1126 S. 70th, P.O.B. 512
Milwaukee, WI 53201

Amerind-MacKissic
Box 111
Parker Ford, PA 19457

Ariens
111 Calumet & 655 W. Ryan St.
Brillion, WI 54110

Atlas Tool & Mfg. Co.
5151 Natural Bridge Ave.
St. Louis, MO 63115

Bolens Div. FMC Corp.
Urban/Suburban Power Equipment Div.
215 S. Park St.
Port Washington, WI 53074

Columbia
P.O. Box 2741, 5389 W. 130th St.
Cleveland, OH 44111

Gilson Brothers Mfg. Co.
Box 152
Plymouth, WI 53073

Hahn, Inc. Agricultural Products Div.
1625 N. Garvin St.
Evansville, IN 47717

International Harvester
401 N. Michigan Ave.
Chicago, IL 60611

Jacobsen Mfg. Co.
1721 Packard Ave.
Racine, WI 53403

F. D. Kees Mfg. Co.
Box 775, 700 Park Ave.
Beatrice, NB 68310

Lindig Mfg. Corp.
Box 111, 1877 W. County Rd. C
St. Paul, MN 55113

Magna American Corp.
Box 90, Hwy. 18
Raymond, MS 39150

McDonough Power Equipment, Inc.
Macon Rd.
McDonough, GA 30253

MTD Products, Inc.
Box 2741, 5389 W. 130th
Cleveland, OH 44111

Red Cross Mfg. Corp.
Box 111, 124 S. Oak
Bluffton, IN 46714

Roof Mfg. Co.
1011 W. Howard St.
Pontiac, IL 61764

Roper Sales Corp.
1905 W. Court St.
Kankakee, IL 60901

Roto-Hoe & Sprayer Co.
100 Auburn Rd., Rt. 87
Newbury, OH 44065

Royer Foundry & Machine Co.
158 Pringle St.
Kingston, PA 18704

Sears, Roebuck & Co.
925 S. Homan Ave.
Chicago, IL 60607

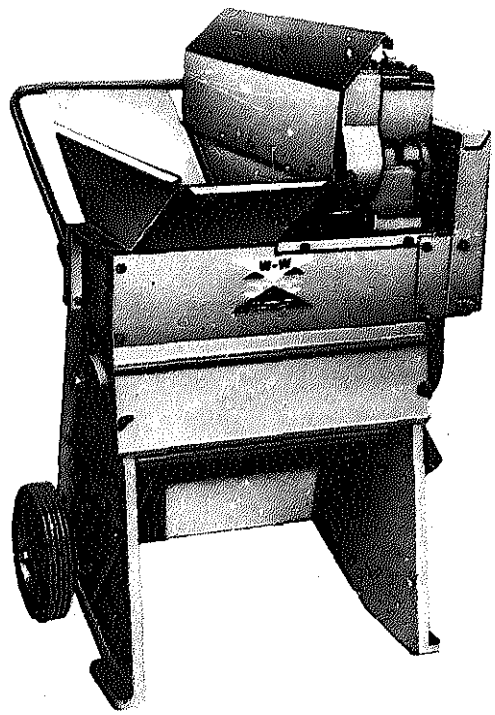
Toro Co.
8111 Lyndale Ave. S
Bloomington, MN 55420

Winona Attrition Mill
1009 W. Fifth St.
Winona, MN 55987

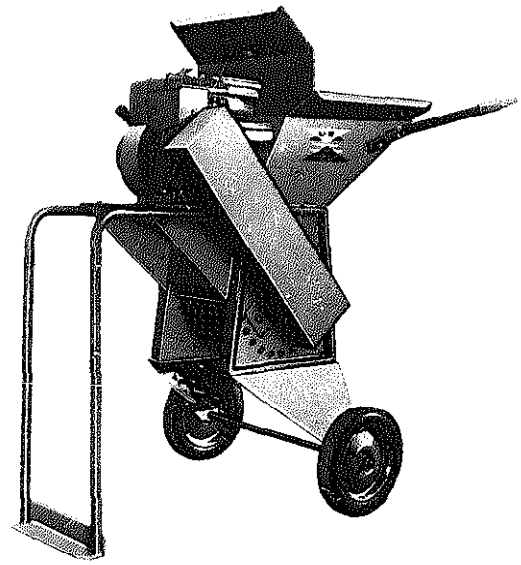
W-W Grinder Corp.
2957 N. Market St.
Wichita, KS 67219



W-W Grinder Model 5-20-4
W-W Grinder Corp.



W-W Grinder Model 2 + 62
W-W Grinder Corp.



W-W Grinder Economy Model A
W-W Grinder Corp.

MULCHING

Mulching is an important technique employed by the organic farmer for maintaining weed control, retaining of soil moisture, and increasing the amount of organic matter or humus present, hence improving the soil's tilth. Specially adapted lawn mowers are good for chopping grasses and weeds for mulch on a small scale. But we know of only one source of equipment for applying mulch on a serious scale.

SOURCES OF MULCHING EQUIPMENT

Rotary Mulching Mower
Manufactured by:
FMC Corp., Outdoor Power Equipment Div.
215 S. Park St.
Port Washington, WI 53074

Rotary Mulching Mower Conversion Plans

Plans for converting a lawn mower are available from:
Dorsay Poor Man's Catalog 3
240 Kinderkamack Rd.
Oradell, NJ 07649



Down to a science: Ralf Clark and Fred Behringer of Waterford, Connecticut, keep the wood stacked high a year ahead of time to dry, use it as a barrier against the weather, and have the system arranged with pulleys so that their sugaring project stays a one-man job.

GOLD IN THE TREES

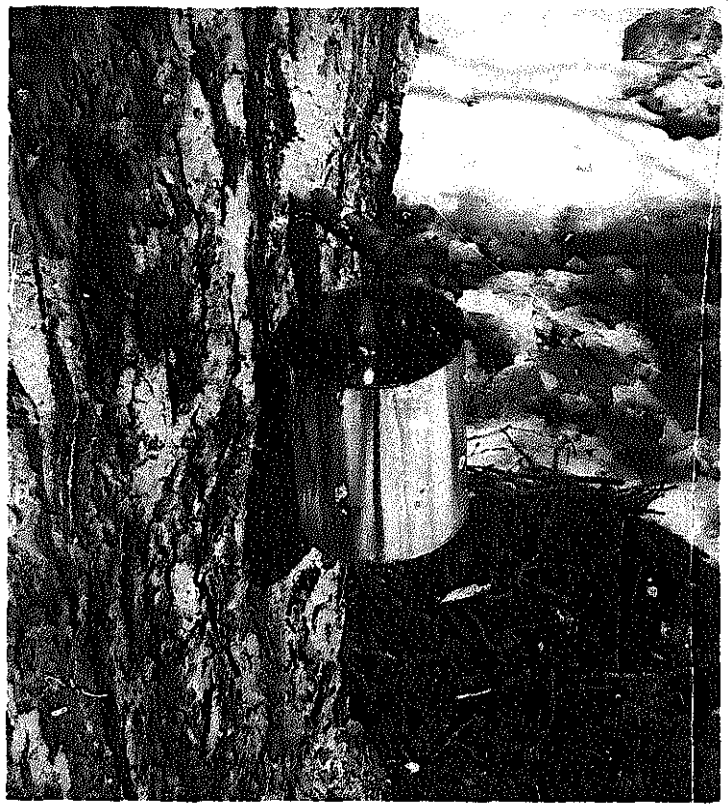
by Bruce Mays

Two years ago, my neighbor and I devised a system that yields three gallons of maple syrup every year from a total investment of under 12 dollars. If we can do it, anyone can. Boiling your own maple syrup is surprisingly easy. And when that syrup is free, boiled during the first hint of spring in your own backyard, you know you're living well.

Sugar sap is manufactured by maple leaves all summer long, then stored for the winter in the roots. The following year, that sugar supplies a ready-made energy reserve to the growing tree until new leaves are able to photosynthesize their own. During the first thaws of spring, the roots must move that sap through the trunk to the branches. Only if conditions are right, only if the sap is racing like an elevator between the roots and branches, can the tree be bled. Warm, sunny days draw the sap from the earth. Freezing nights pull it back down. That combination is essential; any other locks the sap motionless in one spot or another. In the South, or by late spring, there are no freezing nights that will gather the sap to the roots. But don't despair. If you live in sugar country and the season is right, there is no mistaking it. Morning ice will cover the bark, and by afternoon, the branches will sweat with glistening sap.

The first step in sugar production involves drilling holes through the bark. A general rule of thumb calls for the holes to be drilled no closer than one foot apart in a waist-high circumference around the trunk. Each year the holes should be shifted three inches to one side or the other, making sure no new holes are above or below the old. Since sap flows only through the newest growth directly beneath the bark, the holes should be angled upward no deeper than three inches toward the center of the tree. Tap primarily the southern face: sunlight coaxes a quicker flow. The standard drill bit is $\frac{7}{16}$ inch; hardware store taps are made with that size in mind.

A tap is nothing more than a stiff pipe plugged into the hole that funnels the sap out of the tree. Any tubular, soft piece of wood will do. My own yard abounds with one-inch diameter sumac trees. Once the branches have been cut into six-inch lengths, it is a simple matter to ram a red-hot straight iron through the spongy pith. All that remains is to whittle one end of the shaft to a taper and drive the tapered end into the tap hole like a bung into a barrel of wine. The sumac will swell with the first run of sap, sealing the tap tightly against each hole. Professional buckets are made of



The top shaft should be tapered at one end and driven into the tree at an angle. It is best to have a covered collection can.

galvanized steel, come complete with a hood to keep out unwanted rain and snow, are very handsome, and cost $4 each. For that price, I can empty ugly homemade buckets every time it rains or snows. A friend of my neighbor's gave him three dozen unused number ten tin cans—for free. Any large container will do, of course. The tin cans were simply the most convenient for us. I have seen plastic gallon milk jugs and unused paint-stirring cans used with great success. By punching a hole on each side near the top and looping a length of wire between them, we produced three dozen collecting buckets in less than an hour. And when we hung the buckets from our homemade taps, the fit was extraordinary. Forty-nine-cent taps stick out only about an inch from the bark; our homemade variety extends five inches from the trunk, far enough to direct sap into the very center of each bucket. By carving a small notch near the end of each tap, the collecting cans were safe from even the strongest breezes.

Our total investment so far was nothing. By the second week of March, our taps carried clear sap in a stream, filling each two-quart can within hours. And if you hate the thought of all that boiling, stop there—maple sap in place of water makes the most exquisite tea and coffee you've ever tasted.

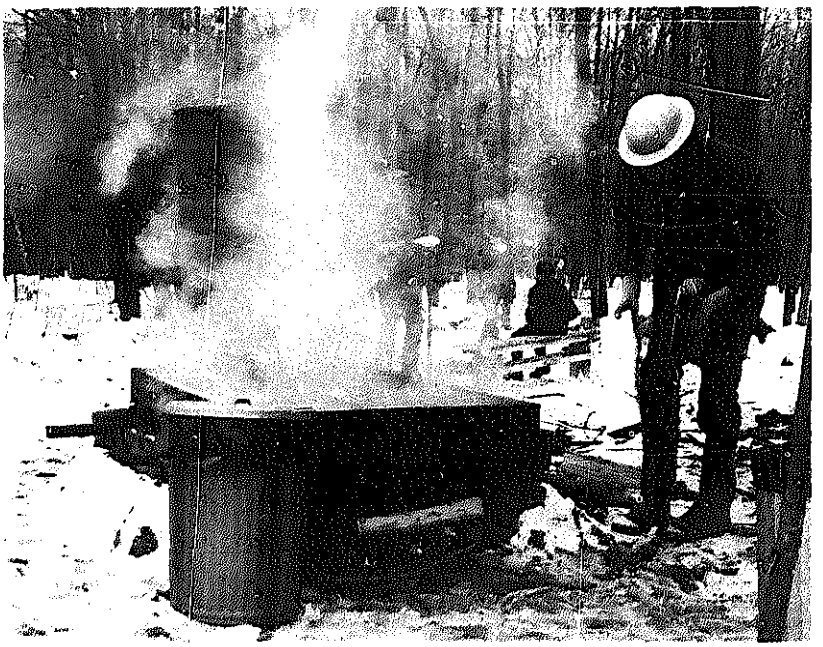
If you do boil it, there are a few considerations to prepare for before you begin. If you have a job during the week, you will probably want to boil only on the weekends. That means storing your daily collections for at least six days. Twenty-gallon trash cans with plastic liners are about as large a storage container as you want to get and still be able to move them easily.

Now, however, you must keep the sap cold during the week. Left by itself, on a warm day, collected sap soon clouds to a bacterial soup. The easiest solution is to keep the trash cans in daylong shade. Each night, a skim of ice will form to protect the sap during the following day. And when warm weather still threatened to melt the ice and spoil the sap, we simply froze some fresh sap

overnight in milk cartons and floated the chunks of ice in the cans. As long as even a small ice cube remained until dark we knew we were safe.

After eight days of collecting we were ready to boil. Once again, we were in a potentially expensive situation. From every 40 gallons of sap, 39 gallons of water must be evaporated. That takes a tremendous amount of heat. The only realistic way for a home maple boiler to produce syrup is to cook the sap over an outdoor wood fire. Our three gallons of syrup demanded about two cords of wood.

Four years ago, I used an old ten-gallon lobster pot for the actual boiling. For someone with only a few maple trees, this is fine. But remember, it takes 40 gallons of sap to produce one gallon of syrup, and the evaporation rate of that excess water is a direct product of the size of the pot. Water will evaporate only from a surface in contact with the air; no amount of heat can alter that fundamental rule. Anyone planning to produce more than a pint of syrup in less than a lifetime of boiling will be forced to use a professional evaporator. We were, and now I know we were right.



From every 40 gallons of sap, 39 gallons of water must be boiled off. Three gallons of sap call for about two cords of wood.

Don't let the word professional scare you. It means simply a very large pan. The smallest of them, like ours, is about five feet long by three feet wide and ten inches deep. That is enough to hold 50 gallons of sap and presents an evaporating surface of 15 square feet—a twenty-fold improvement over my lobster pot. Fancier, more expensive evaporators have baffled compartments to route the finished syrup away from the new sap, inlet spigots and outlet faucets, and mysterious coils winding along the bottom. But beyond all that finery is still the simple physics of a larger evaporating surface. My neighbor found our small, used pan in a local newspaper for $10. Five dollars each, and we had made our last expenditure.

It remains only to get the fire underneath the pan. In our case, that meant piling used bricks in a three-sided structure 18 inches high, making sure that the edges of the evaporator pan would sit snugly on the inner brick wall. I suppose the bricks should be cross-stacked for maximum strength, but by the time we set the pan, leveled it out, poured in the sap, and stoked two cords of wood, our neat rectangle was something of a shambles anyway. The real trick is to concentrate as much of the heat uniformly onto the pan while still allowing enough air into the blaze to keep it burning hot. That meant removing a stray brick for ventilation here and there, sticking an old stove pipe from

the back end as a chimney, maybe sealing the gap between the evaporator and the bricks with mud. Generally, though, it meant just watching the fire at all times to balance its needs.

There are some things to be remembered during your boiling day. If the boil slows, the evaporation rate decreases. Too much heat in one spot tends to melt the solder holding the pan seams together. You have to work on the furnace a little to prevent those annoyances. We slanted a dug pit towards the rear of our rectangle and tried to keep most of the burning wood near the bottom. The heat then tends to climb up the slope towards the mouth of the furnace and disperse somewhat evenly across the bottom of the pan.

Be sure to add fresh sap steadily throughout the boiling. Too much cold sap all at one time will quench your good boil and slow the evaporation rate. Each time new sap is added, a scum will rise to the top. Skim these impurities from the broth with a slotted spoon.

Finally, the sap will taste distinctly mapley. Since our three gallons of syrup made a dangerously shallow layer in the pan, we found it prudent to remove the syrup from the fire when it was obviously brown and sticky-sweet, but still too thin for good syrup. This meant boiling the last few gallons in pots on the kitchen stove, but that way you can watch the syrup more carefully as it thickens. Books will tell you to dip in candy thermometers, or to measure the specific gravity and weigh the sugar content. At that point, the usual rolling boil is replaced by a kind of brown foam that sudses above the syrup. Syrup at just the right stage will cling to the spoon like thin taffy as it cools.

Your new syrup should be poured through muslin or felt at least once to pick up stray flecks of ash left by the fire. If you're planning to store the syrup for longer than a few months, be sure to fill each container right to the top while still hot and cap it immediately. When the syrup cools, it will hold the cap down with vacuum and never spoil. Pint or quart mason jars are perfect for this, but old bottles or food jars—anything with a sealing lid—can be used. If the syrup ever does cloud, simply boil it again and rebottle it. In a cool spot it should keep for years.

By the end of the day everyone is exhausted. Last year we began at six in the morning and were still sitting in a freezing drizzle at eleven o'clock that night. In between, a half ton of sap was poured by cupfuls into the steaming evaporator, the fire was tended, new sap was collected, and spare wood split.

And yet every winter I am restless for sugaring season. By late February, I swear I can smell the sweet air from other boilers. There is something very special about this first outdoor project of the year, something very satisfying about using your hands and brains to produce such an indecently delicious syrup.

NUT SHELLERS

GROUNDNUT DECORTICATORS

Groundnuts, peanuts for example, have fibrous cellulose shells which need to be removed prior to consumption. The task requires a rubbing-stripping action and a method for cleaning. Most hand-operated decorticators do not do this and so require a separate winnowing step.

SOURCES OF MANUAL DECORTICATING EQUIPMENT

Handy Groundnut Decorticator

Built from steel and cast iron, the Handy is simple to operate and easily transported. Nuts are placed in a receptacle and the operating handle moves forward and backward, rubbing the nuts against spiked rustlers and the shelling grid. Kernels are not separated from the shells after decortication with this device.

Harrap Wilkinson, Ltd.
5 North Phoebe Street
Salford M5 4EA, U.K.

R. Hunt and Company Groundnut Decorticator

The distance between the galvanized, heavy mesh screen and the rubbing bars on this unit can be adjusted to accommodate a variety of sizes of nuts. Four different sizes of screen are available for this hand-operated sheller.

R. Hunt & Co., Ltd.
Atlas Works, Earls Colne
Colchester, Essex CO6 2EP, U.K.

CeCoCo Model 300D Peanut Sheller

In this model, revolving beaters shell the peanuts, and kernels are separated from the shells by a screen and fan. Output is 40 to 50 kilograms per hour, and kernel breakage is 2 to 3 percent.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Groundnut Sheller

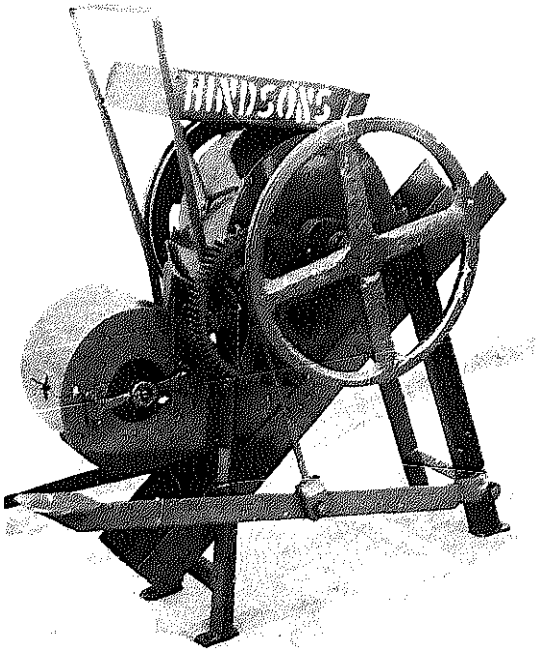
A hand-operated groundnut sheller is available from:

Ubungo Farm Implements
P.O. Box 2669
Dar Es Salaam, Tanzania

Hand-Operated Groundnut Decorticator

For more information write to:

Dandekar Brothers
Sangli
Maharashtra, India



Hindsons Treadle Power Groundnut Decorticator
M/s. Hindsons Pvt., Ltd.

Hindsons Groundnut Sheller

This is a foot-operated, portable device designed to quickly separate nuts from their shells. The balanced flywheel eases operation, and the blower separates shells from the nuts. Maximum output of the unit is 441 pounds per 8-hour day.

M/s. Hindsons Private, Ltd.
The Lower Mall
Patiala, India

SOURCES OF POWER-DRIVEN SHELLING MACHINERY

CeCoCo Peanut Sheller

In the CeCoCo sheller, threshed and cleaned peanuts are shelled by a revolving beater mechanism. After being run through the machine, unshelled and shelled peanuts are separated with a fan and screen. Unshelled nuts should go back in the implement until shelling is complete. Breakage of kernels is between 2 and 3 percent. Four model types are available using 1, 2, or 3 h.p. motors and with outputs of 120 to 420 kilograms per hour depending on the model.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

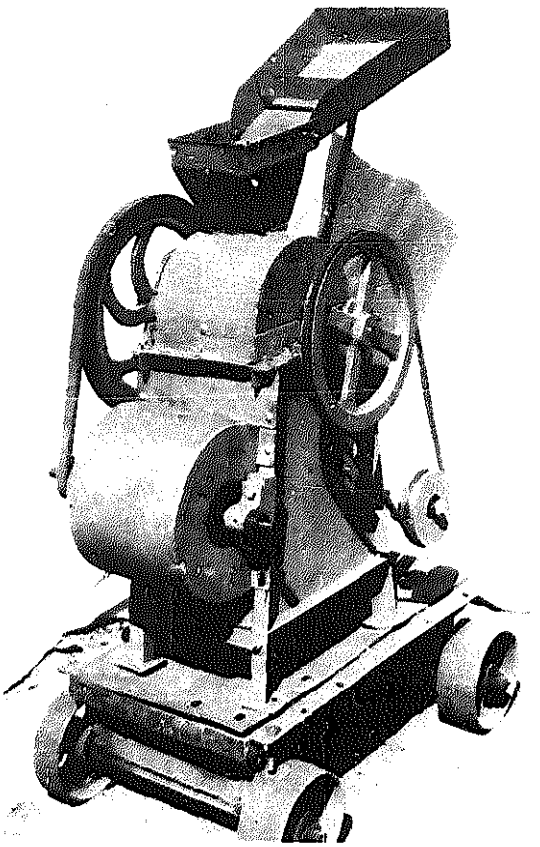
Harrap Wilkinson, Ltd. Automatic Groundnut Decorticator

Nuts to be shelled are placed in a hopper at the top of this machine. The nuts pass into a beater chamber by means of a ribbed feed roller; the rate is adjustable. Rotating, flexible beaters break the shells, and a blower mechanism separates the shells so that only the kernels are in the delivery chute. Wilkinson's No. 2 machine has a 1½ h.p. motor and an output of 254 to 406 kilograms per hour.

Harrap Wilkinson, Ltd.
North Phoebe St.
Salford M5 4EA, U.K.

Dandekar Brothers Groundnut Decorticator

Dandekar Brothers manufactures four types of power-driven decorticators. Type A needs a 5 h.p. motor and has an output of 80 (180 pound) bags per (12 hour) day. Type B requires a 6 h.p.



Dandekar Power Groundnut Decorticator
Dandekar Brothers

motor and will produce up to 100 bags a day. Type C is powered by a 7 h.p. motor and will shell up to 120 bags per day, and Type D uses a 10 h.p. motor for a maximum output of 200 bags per day. The hopper is on the upper part of the machine. Nuts pass from there into an opener cylinder where the shells are broken and separated from the kernels. The shelled nuts fall on the ground to be collected.

Dandekar Brothers
Sangli
Maharashtra, India

SINGLE NUT NUTCRACKERS

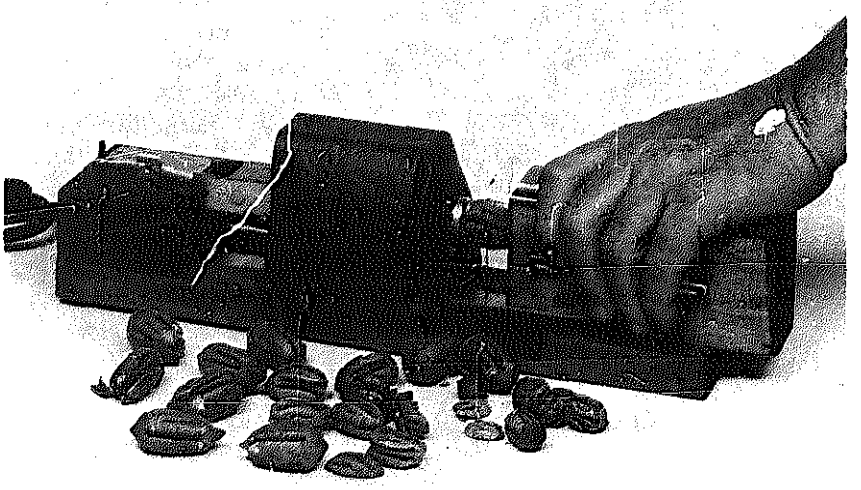
New Dynamic Nut Cracker

Designed to crack any size nuts except hickory nuts or hard-shell walnuts, this sheller locks and cracks them automatically. Kernels and shells fall out for rapid repeats, and the safety shield protects the operator from flying shell particles. This electrically operated device requires 110 volts and 60 cycle alternating current. The cracker is guaranteed for 1 year, and has an estimated life of 10,000 pounds of nuts.

L.H. Powell
8647 Wingate Drive
Dallas, TX 75209

Texas Native Inertia Nutcracker

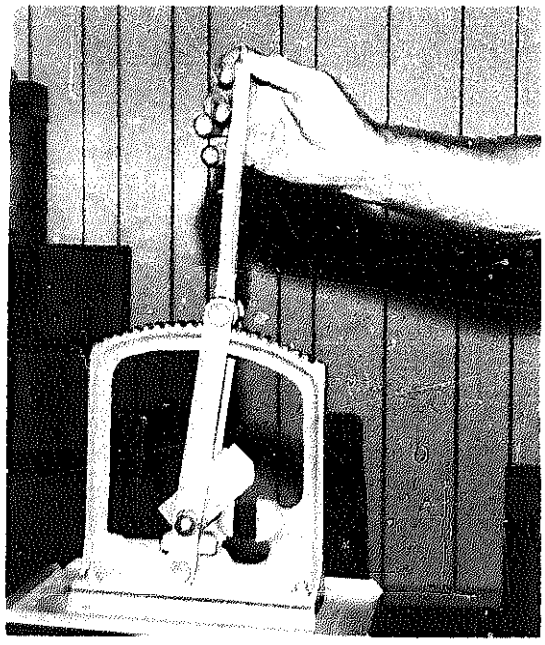
Made of oak and aluminum, this device will



Texas Inertia Nutcracker
R.P. Industries, Inc.

crack any type of pecan, Brazil nut, filbert, almond, macadamia, and English or California walnut. The cracker operates by placing the nut between two sockets, pulling the safety shield over the nut, pulling back the knocker stick, and releasing it. The kernel is left in the sockets, and the shell falls away from it. The tool is guaranteed for 1 year, and can crack up to 30 nuts in a minute.

R.P. Industries, Inc.
610 W. Johnson St., P.O. Drawer 10933
Raleigh, NC 27603



The Potter Walnut Cracker
Fred Klingensmith, Inc.

Potter Walnut Cracker

This device cracks walnuts one at a time. Heavy-duty crackers are also available.

Fred Klingensmith, Inc.
Sapulpa, OK 74066

RICE HULLING

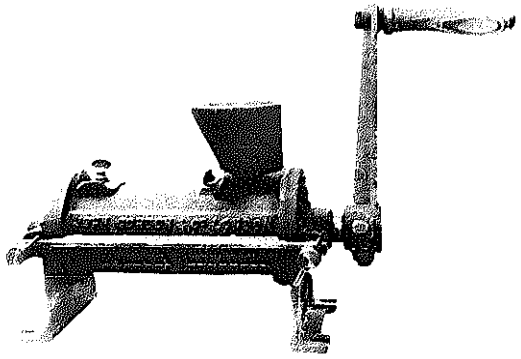
Similar to wheat, rice grows with a bran layer and an outer hull covering the kernel. For the grain to be edible, the hull must be removed in the hulling process. An unnecessary second step, polishing, removes the bran and the germ, and along with them, much of the grain's B-vitamin content. Rice that is hulled but unpolished is called brown rice. Both the hulling and polishing processes require a milling action, often by two rollers rubbing the kernel between them. Most hullers are designed for power operation, but a few hand-operated models are still being made.

SOURCES OF RICE HULLERS

Java Hand-Powered Rice Huller

This is a small machine intended for the grower of small quantities of rice paddy, and for domestic use. It replaces a model called the Paddy Pounder. Paddy can be shelled at a maximum rate of about 30 pounds (14 kilograms) an hour, but the capacity may vary considerably depending on the type of rice and its condition. The machine has three adjustments controlling the feed, the discharge, and the hulling knife. A perforated plate allows dust to escape, and the machine can be opened easily for cleaning. Strongly made, its net weight is 23 pounds (10.5 kilograms), and it is provided with holding-down screws and spanners.

John Gordon & Co. (Engineers, Ltd.)
196a High St.
Epping, Essex CM16 4AQ, U.K.

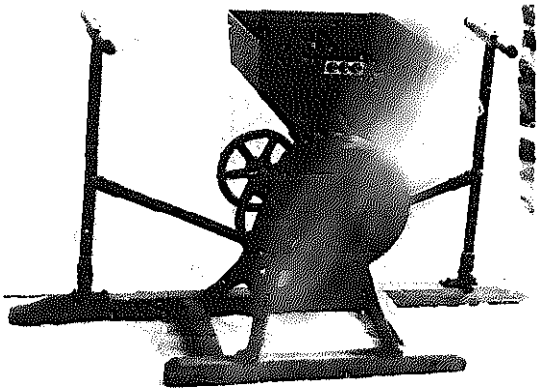


Java Hand-Powered Rice Huller
John Gordon

CeCoCo Two-Man Rice Huller

Two men operating the hand levers will rotate this huller at 3,500 to 4,000 rpm, hulling

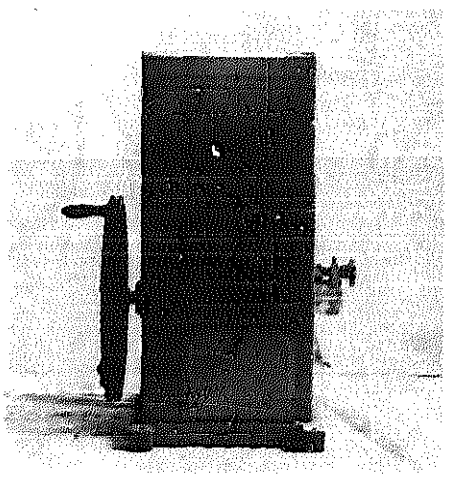
250 kilograms per hour with 90 percent hulling efficiency. Net weight: 60 kilograms.



CeCoCo Two-Man Rice Huller

CeCoCo Hand Rice Polisher Type E

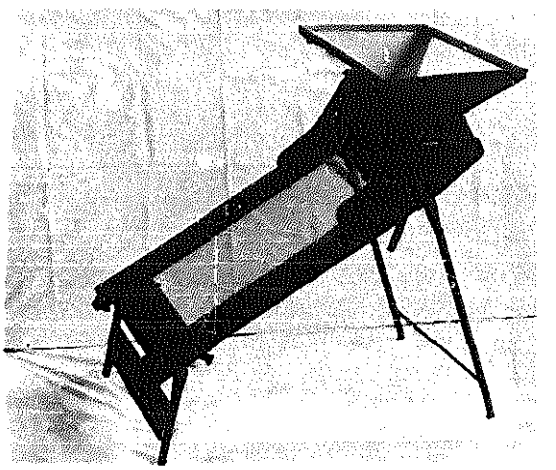
Operated either by hand or by a ¼ h.p. motor, the Type E Polisher will polish unhulled rice that has already been dried and winnowed. Capacity is 10 to 15 kilograms per hour by hand, and 30 kilograms with a motor. Weight: 22 kilograms.



CeCoCo Hand Rice Polisher Type E

CeCoCo Hand-Hulled Rice Separator and Sorter

Constructed of steel and easily dismantled for storage, the four models of this sorter have capacities ranging from 20 to 32 bushels per hour. Hulled rice is fed into a hopper, and while sliding across the surface of the piano-wire screen, it will separate into whole hulled rice, unhulled rice, unhulled paddy rice and immature rice, mud, and sand. It may also be used to sort polished rice for grading.



CeCoCo Hand-Hulled Rice Separator and Sorter

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

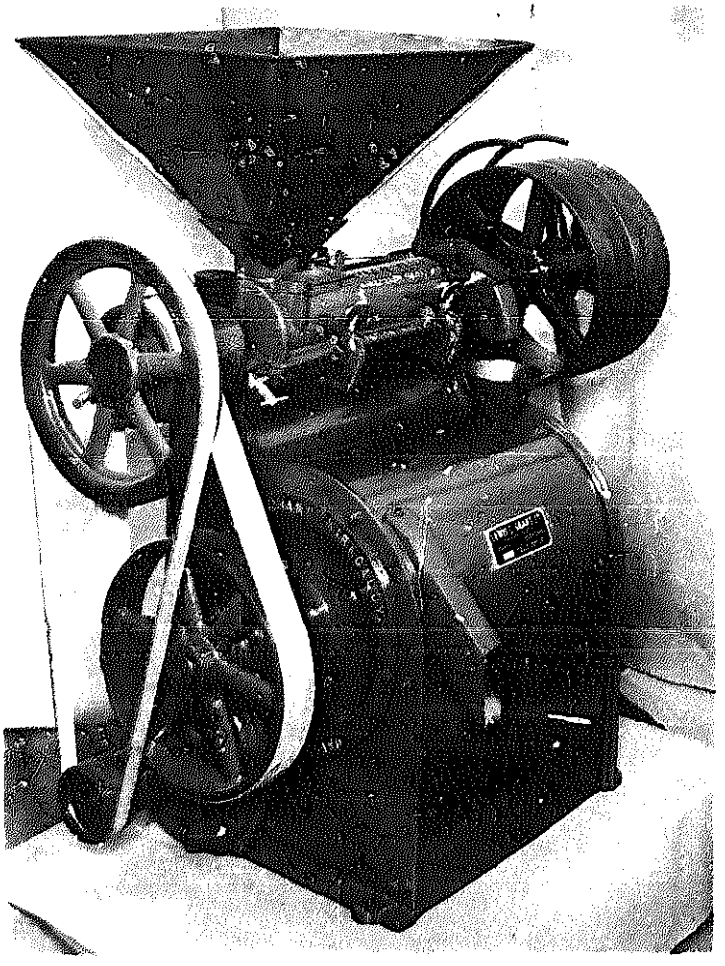
Amuda Rice Hullers

These power-driven machines can be used as hullers alone or supplied with polishing attachments. Three models are available, requiring 5, 12, or 15 h.p. They will hull rice from the paddy or shelled rice. From the paddy, the smallest huller will produce 36 to 45 pounds of cleaned rice; the middle, 136 to 204 pounds; the largest, 250 to 295 pounds per hour. When using shelled rice, production capacity is a little less than double those amounts per hour.

Rajan Trading Co.
P.O. Box 250
Madras 600 001, India

Grantex Rice Hullers

Three sizes of Grantex hullers are made. The smallest, requiring 5 h.p., produces 80 to 100 pounds of polished rice per hour. The amount is doubled if shelled rice is being polished. The two larger models utilize 12 and 15 h.p., respectively; they produce 300 to 450 and 500 to 650 pounds per hour. The two larger models can



Grantex Rice Huller
Lewis C. Grant, Ltd.

produce five separate products directly from the paddy: white rice, coarse meal, fine flour, bran, and husk. Optional extras include polishers, aspirators, fans, drive units, and reciprocating sieves.

Lewis C. Grant, Ltd.
East Quality St., Dysart
Kirkcaldy, Fife, KYI 2UA U.K.

Iseki Rice Polishers

The Iseki Model JE25 is an automatic, cabinet body machine. Horsepower required to operate the polisher is 4 to 5, and 300 to 350 kilograms of rice can be polished per hour. The manufacturers recommend combined use with a rice huller, but state that it can also be used as a rice-hulling and -polishing machine. Three larger models are available, either in cabinet or strip enclosures. Efficiency ranges from 300 to 1,000 kilograms per hour. None of the Iseki models include their own power units.

Iseki Agricultural Machinery Mfg. Co., Ltd.
1-3, Nihonbashi 2-chome, Chuo-ku
Tokyo, 103 Japan

CeCoCo Automatic Rice Hullers and Combinations

CeCoCo, with its wide variety of all types of machines, offers seven automatic rice processors, with many sizes of each type. Their automatic hullers feature rubber rollers, which they claim will increase output recovery of hulled rice 15 to 20 percent. They also recommend that rubber-rolled rice be stored and shipped as brown rice,

with any polishing to be done at the destination of the shipment to avoid deterioration of the product.

1. Rubber Roll Rice Huller: The original model consists of a hulling head and installation bed. Separation of brown rice and husks is necessary. Seven models are available, ultilizing 1 to 10 h.p. or V-belt drive: capacities range from 500 to 4,000 kilograms per hour in paddy.
2. Combination: Three models, with or without suction husk exhaust, are offered. The basic unit includes a huller and husk winnower. The suction exhaust model is recommended for use in buildings. The three sizes utilize from 2 to 5 h.p., with capacities ranging from 500 to 2,000 kilograms per hour.
3. Automatic KL-A: This self-contained unit includes hulling head, winnower, double elevator, separator, and rice elevator. The smaller model requires 4 to 5 h.p. and produces 600 to 700 kilograms per hour; the larger requires 5 to 6 h.p. and produces 1,000 to 1,200 kilograms per hour.
4. Automatic AM and ME: These are miniaturized versions of the complete unit, suitable for a single farmer or a group of farmers. The one-body construction includes huller, winnower, and separator.

Three larger rubber roller units, having hourly capacities of 1,200 to 4,000 kilograms, are also available.

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Nogueira Rural Rice Mill

The Nogueira Rice Mill husks and polishes rice, then separates polished rice, husks, rice bran, and broken rice. It will utilize a 3 h.p. electric motor, a 6 to 9 h.p. gasoline motor or a 5 to 8 h.p. diesel-oil motor. Production capacity is approximately 2 sacks (60 kilos or 132 pounds) per hour. The cabinet is metal and weighs 236 kilograms.

CIMAG: Comercio e Industria de Maquinas Agricolas Ltda.
Rua Padre Roque no.° 1,840, Mogi-Mirim S.P.
Brazil

Genuine Engelberg Combined Rice Huller and Polisher Number 3

Powered by flat belt-drive pulley, this 3 h.p. machine will, in a single operation, hull, scour, and polish rice as it is received from the thresher. An optional built-on exhauster is available to carry away chaff and dust.

This item is suggested for small mill operators or larger growers. The No. 3 has a capacity of 80 to 100 pounds of rough rice per hour, and two larger models are capable of up to 700 pounds per hour.

Genuine Engleberg Huller Number 4

Similar in design to the No. 3 Rice Huller and Polisher, the No. 4 does not contain the polisher attachment. Two larger models of hullers are also available.

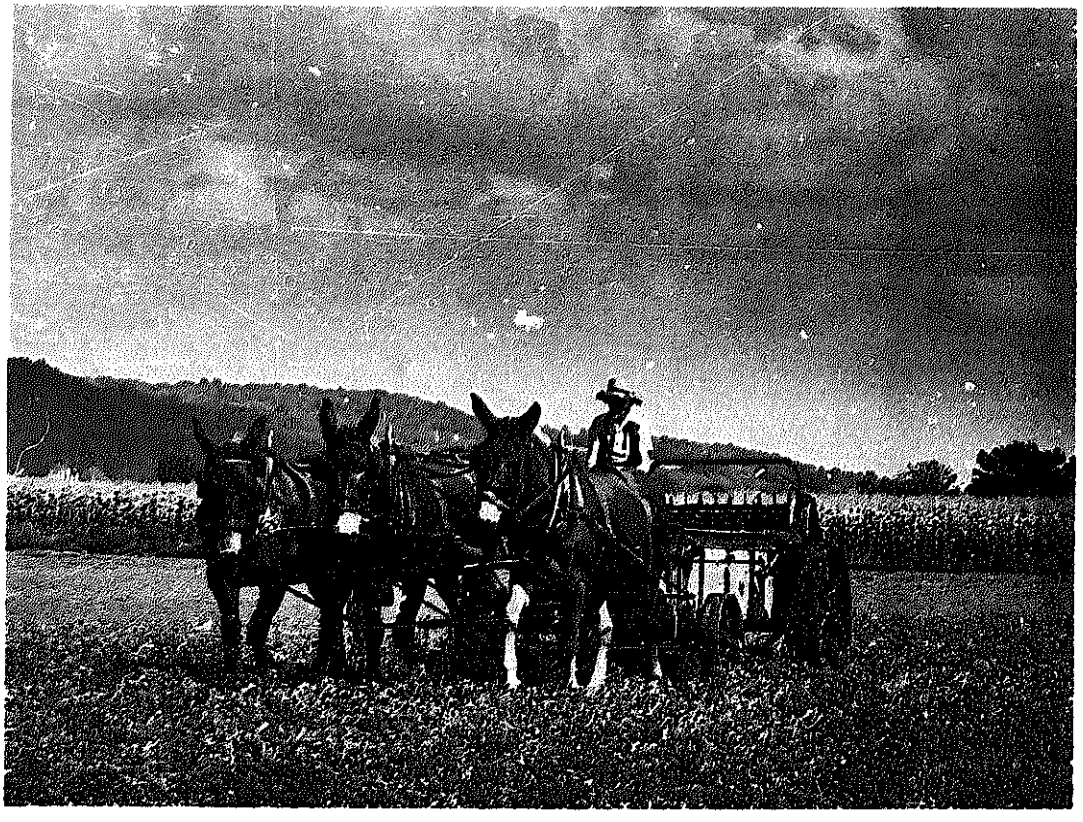
Engleberg Huller Co. Division
P.O. Box 277
Factoryville, PA 18419

-9- Tools for Adding Organic Matter to the Soil

To the practitioners of today's chemical agriculture, a fertilizer is a substance that has a measurable quantity of at least one of the major nutrients required by growing plants. The most widely used chemical fertilizers are those which contain three primary plant nutrients: nitrogen (N), phosphorus (P), and potassium (K) in varying combinations.

Organic growers, on the other hand, rely on natural fertilizers to maintain and replenish all the elements in their soil that are necessary to plant growth. They view soil fertility as a broader, more complex concept which involves not only specific plant nutrients, but also organic matter, the living organisms present in the soil, and the very structure of the soil itself. To them, humus content and tilth are important aspects of soil fertility. Unlike those farmers who employ chemical fertilizers to supply their crops with specific nutrients in forms that are readily available, organic farmers use a variety of natural materials to maintain and improve overall soil quality. In this way, soil fertility and health are improved even as crop yields increase.

Direct application of livestock manures has been the farmer's traditional approach to return-



Mule-Drawn Manure Spreader
Reading Eagle, Lancaster County, Pa.

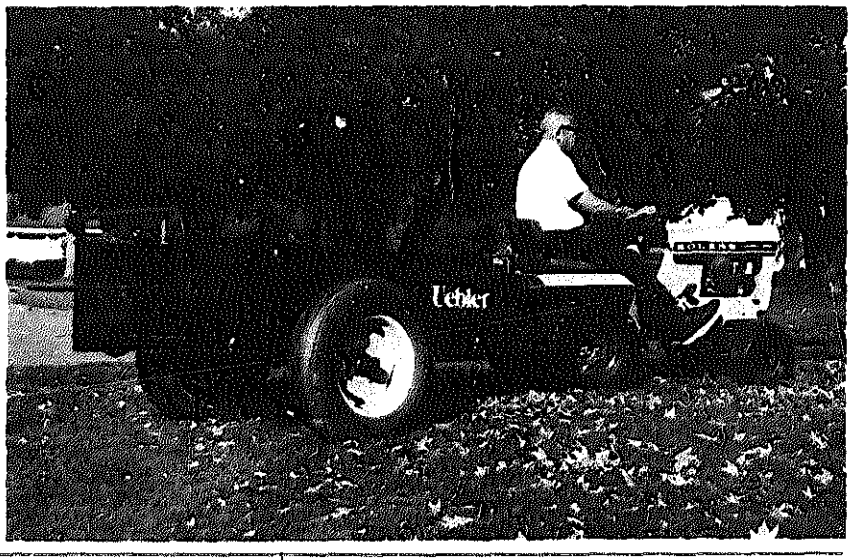
ing organic materials to the soil. Originally, manure was spread over the soil surface from a cart, with a many-tined pitchfork called a manure fork. Then came the development of the manure spreader, a horse-drawn cart with a ground-driven set of chopping blades in the rear. Manure fed into the blades was chopped into small pieces and evenly distributed onto the field.

SOURCES OF MANURE SPREADERS

Most manure spreaders made today are designed for pulling behind large tractors beyond the scope of this book. They are easy to locate through most agricultural equipment dealers. Farm auctions are the best source for smaller units in North America.

Uebler Mini

One company to appear with a mini manure spreader, requiring only the power of an 8 to 12 h.p. tractor, is Uebler. Their smallest model has a capacity of 18 bushels which it distributes under power from its own 4 h.p. gasoline engine or a power take-off shaft. Their next size larger has a 50-bushel capacity.



Uebler Mini Manure Spreader
Uebler Manufacturing Co.

Uebler Mfg. Co.
Vernon, NY 13476

New Idea

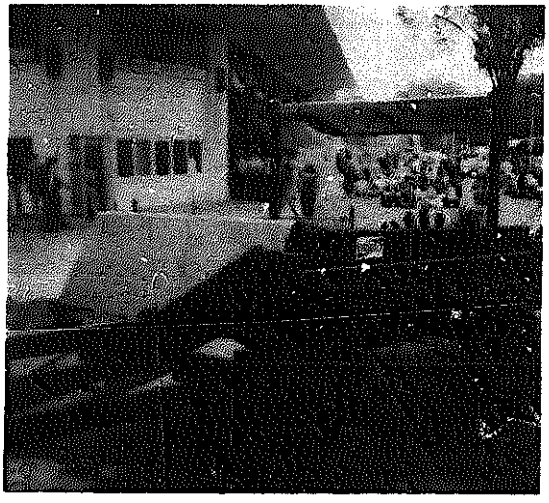
The smallest manure spreaders put out by New Idea are a 138-bushel model with the combined chopping action of a cylinder and paddle, and a 146-bushel, single-beater model.

AVCO. New Idea Corp.,
Farm Equipment Div.
First & Sycamore
Coldwater, OH 45828

OrBilt Manure Spreader

The main beater of this spreader is made from heavy channel iron. These channels are welded around the beater pipe in two opposing spirals. This beater will tear apart the toughest manure, whether it is from a feedlot or pen, even if it is frozen. Strings don't catch or hang on this beater as they do on others. A lower-splash blade beater has the specific purpose of breaking up and scattering both liquid and clumps. This lower beater is particularly useful if you are spreading on a hay field or some other place where large lumps could smother patches of a crop.

The sliding pusher and false front endgate move as one unit to the rear of the box. The speed is controlled from the tractor seat by a variable flow, hydraulic valve. The pusher, replacing the traditional conveyer apron, is the heart of the entire machine. Part of the hydraulic cylinder is enclosed by the center housing



OrBilt Manure Spreader
O'Reilly Manufacturing

of the sliding pusher; the other part extends out over the tractor hitch. The entire inside of the box is lined with tough plastic. Manure does not penetrate or stick to the plastic, nor does it freeze to plastic as it does to wood or steel.

O'Reilly Manufacturing
Rt. 3
Goodhue, MN 55027

Prototype Material Spreader

Charles E. Fox, of Jonesboro, Louisiana, has invented a spreader wagon that hitches to a tractor and distributes material such as pulverized chicken fertilizer, sawdust, or ground bark. It is a two-wheeled cart with a series of arched platforms in its bed that funnel material onto a conveyor belt, and then through a gauging or measuring device. The gauge limits the amount of material laid per foot. The belt can be disconnected for transport. Mr. Fox is currently seeking a manufacturer for his spreader with the help and guidance of the Raymond Lee Organization. His invention, covered by a patent application pending in the United States Patent Office, is designed primarily for organic farmers.

Charles Fox
Rt. 3, Box 77
Jonesboro, LA 71251

Raymond Lee Organization, Inc.
230 Park Ave.
New York, NY 10017

COMPOSTING

Manure spreaders are still a necessary tool on the organic farm, but increasingly they are being used to spread composted manures and other organic wastes. Composting is the biological process of decomposition during which wastes are broken down into their basic chemical parts and made ready to be used again in building another plant. The product is called humus.

With the proper microorganisms present in the soil, humus will evolve by simply applying organic wastes to the soil surface. However, composting speeds the process, and by following a basic composting recipe, a more-balanced nutrient fertilizer is produced.

COMPOSTING AS A MANURE MANAGEMENT SYSTEM

by Richard Thompson

Editor's note: Richard Thompson was born and raised on his present farmstead, consisting of 300 acres outside Boone, Iowa. He graduated from Iowa State University with a B.S. in Animal Husbandry and an M.S. in Animal Production.

Composting, in my opinion, is a sensible, practical, economical way to deal with animal waste on the farm. My reasons for starting to compost followed the same pattern as my reasons for changing to organic farming back in 1967, namely—problems.

Back then I was on a continuous corn program, applying chemical N-P-K, herbicides, and insecticides. The fences were removed from between the fields, cattle were brought in and confined to barns and lots.

We live in a low, flat area so the barns and lots needed to be cemented. This situation brought about all kinds of sickness in the cattle. It seemed like it was just one thing after another. I got to the point where, out of frustration, I said, "There has to be something better than this." In the spring of 1968, we stopped using all chemicals and started putting fences back, so the cattle could have limited pasture. The cropping system was changed to a corn-soybean-corn-oats-hay rotation.

Even with all-chemical N-P-K added to the continuous corn program, I had to dispose of all the manure from the cattle and hogs. Note that I say dispose of, not use. The manure was hauled out of sheds and lots during the winter and early spring, and applied to frozen, plowed fields that were often covered with snow. This was a very poor utilization of the nutrients, especially the nitrogen content in manure which would turn into ammonia, dissipate in the air, and be completely lost. Also the raw manure would move with the melted snow and end up in creeks and rivers, polluting our water supply.

After I stopped using the artificial N-P-K, the corn yields stayed at 120 bushels per acre for the next seven years. The corn yields, previously, were about the same, averaging 120 bushels per acre.

My yields, on the organic program, were oats: 70 to 80 bushels, soybeans: 35 to 45 bushels which, I felt, were good and also competitive with the neighbors. The hay fields also seemed to improve each year. After about seven years of organic farming, the field of corn following soybeans dropped to the 80- to 90-bushel range. The cornfield following hay remained in the 120-bushel range. The profit on the 80- to 90-bushel yield would probably be okay, since the expenses per acre were $40 to $50 lower than those of the neighbors on chemical methods. However, I felt with all this manure and only 80 to 90 bushels, something must be wrong. This was where composting came into the picture.

Composting is a way of turning a liability into an asset on the farm.

In the spring of 1975, we decided not to spread the manure on frozen ground during the winter. The manure was pushed up into large piles in the yards during the winter. On June 5, we started to clean out these piles and haul to our compost site on the edge of the hay field. This manure was cold and had large chunks of ice in it.

A bacteria starter was spread on the manure piles in the yard, loaded in the spreader, and taken to the compost site located centrally between our farmstead and the neighbors'.

The spreader needs to be power take-off-operated so it will unload in a stationary position. When the manure builds up to the beaters, the spreader is moved forward about one foot and the rest of the load is unloaded in this fashion. I feel the ideal pile is about eight feet wide at the bottom and four feet high. In two days' time we saw a miracle happen. This cold, frozen manure which had a temperature of about 30 to 40 degrees heated up to 140 degrees, and steam was coming out of the top of the windrows. I feel that, in my situation with all the manure off concrete, I need the added bacteria to get the action started, as little earth was combined with the manure. We tried some windrows without bacteria and the action was very slow.

One of the important keys to good composting is moisture content. This should be in the 40 to 60 percent range. If the manure is wetter than 60 percent, it will take more turnings with the spreader to get it dried down. If the manure is too dry, water needs to be added. Generally, I take some wet manure and mix it with dry manure and this usually comes out about right. Much has been written about carbon-nitrogen ratios in composting; they should be 20 to 30 parts carbon to one part nitrogen. For the farmer, I think this means simply that what creates a good environment for livestock will make good compost. If cattle or hogs are kept clean and dry with bedding, the carbon-nitrogen ratio will be excellent.

My windrows were turned by reloading the spreader and unloading to make a parallel windrow. The windrows need to be turned until the temperature stays below 100 degrees. However, if it is time to spread on fields, incomplete compost that is still steaming can be applied to fields and disked in the same day. We initially applied four tons of compost per acre in fall after the soybeans were combined and bean straw was stacked. The N-P-K analysis of the compost was 2-1-2.

This year I bought an Easy Over compost-turning attachment for my tractor. With this attachment

I can now turn the more than 500 tons of compost I'm making in an hour, as opposed to the two days it took using the stationary manure spreader and loader. I attach the turner to the hydrostatic PTO of a tractor, and use another tractor to slowly move it along through the windrow.

Before getting the turner, we were somewhat lax about turning our piles, since it took so much time. During the growing season it was often impossible to find the time to give two days to turning compost. Now, time is not a problem. If composting had a drawback, it was always because of the amount of time it took to turn. Turning time is no longer a problem for farmers, thanks to the turner.

Although the turner costs five to six thousand dollars, I still think it's a good investment. On a family farm, time is often the critical commodity, and the turner frees a lot of time. I don't think every farmer should own a turner, and as long as there is one in your area, you can hire it for custom work. The turner is easy to transport on the highway, so moving it is no problem. In fact, we now use ours to do our own composting, in the sewage sludge composting operation my son has set up, and a neighbor uses it to compost chicken manure.

As I stated before, we are dealing with raw, wet manure when we start to compost, so we locate our compost site away from farmsteads. When composting starts, the odor changes to a musty smell and isn't noticeable over 40 rods away from windrows. The fly problem is eliminated when the temperature starts to rise, and these temperatures will also kill weed seeds and harmful pathogenic organisms. As I mentioned before, the compost is applied to my field following soybeans. The planting of corn that followed the soybeans was where we were having the yield reduction problem. Last year, we applied 300 tons of finished compost to the fields. The time required to turn 300 tons three times was 30 hours using two people. This year I'll produce more than 500 tons of compost, with not more than eight or ten hours of labor. The yield response from compost was very encouraging, producing a strong 100 bushels per acre in a dry year. This yield was equal to the corn yields of neighbors who used chemical methods.

SOME SPECIALIZED EQUIPMENT FOR COMPOSTING MANURE

Editor's note: Dennis Demmel of the Small Farm Energy Project in Hartington, Nebraska has supplied much of the information used in this report.

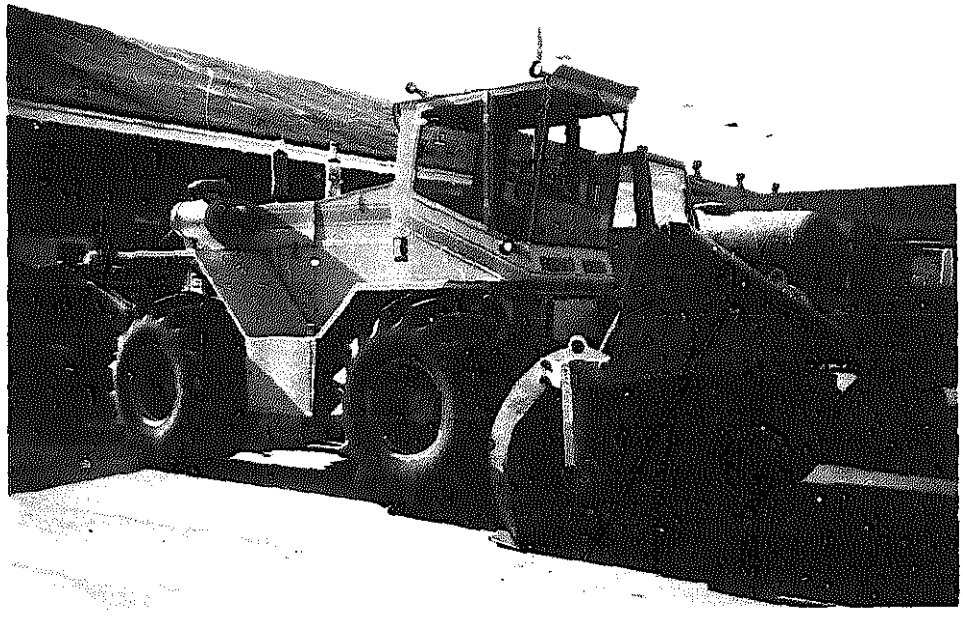
Nebraska is a state that can be said to be blessed—or plagued—with a variety of organic wastes. Its large communities are burdened with paunch manure from slaughterhouses as well as sewage sludge and garbage. Huge piles of dry manure in feedlots or other animal confinement facilities can mean serious dust and odor problems.

In a report in *Farm, Ranch, and Home Quarterly* (Fall, 1977), agronomy professor Leon Chesnin of the University of Nebraska foresees solutions in the near future. His report is entitled "Composting Converts Waste into Valuable Resources," and he writes that "there is a way all of these wastes can be converted into valuable resources—*composting.*" One reason for his optimism is that specialized equipment has been developed to handle large volumes of wastes. Some of this equipment is now in use at the University's Mead Field Station.

The Roscoe Brown Corporation of Lenox, Iowa has supplied a Brown Bear integral auger tractor to the University of Nebraska. The unit is used in composting feedlot manure, paunch manure, sewage sludge, and crop residues.

According to the manufacturer, the Brown Bear can mechanically aerate 3,000 cubic yards per hour—working directly into and parallel with the windrow. In describing the machine's auger speed, the company notes: "By simply changing sprockets, the speed of the auger can be increased to 180 revolutions per minute or more for more aggressive boiling action in the organic waste." The Brown Bear is manufactured by the Roscoe Brown Corporation, P.O. Box 48, Lenox, Iowa 50851.

Edgar Wuebben of Cedar County, Nebraska had a Compost Field Day at his farm last August to demonstrate his home-built compost-turning device. The turner is built from discarded materials,



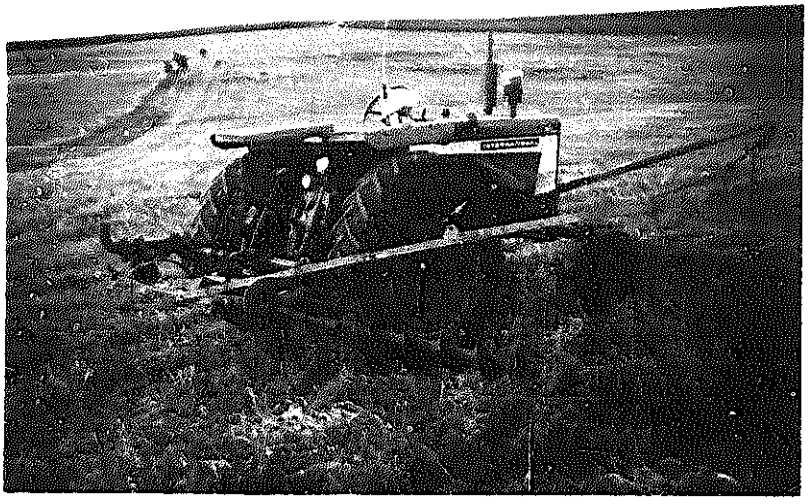
The Brown Bear Integral Auger Tractor



Feedlot manure and crop residues are composted with the aid of the Brown Bear turning machine at the University of Nebraska's Mead Field Station.

including a gearbox, tool bar, and silage-unloading auger. The auger is used to aerate, break up, and mix the pile. Afterwards, a tractor loader is used to repile the materials.

Wuebben has been keeping daily records of the temperatures within the compost at 50 different points along his 500-foot windrow. The records have indicated that the temperatures of the pile rose substantially after each turning and also following rains that occurred between turnings. The increase in temperature following a rain would indicate that the moisture content of the compost wasn't adequate for optimum bacterial activity.



Edgar Wuebben's home-built compost turner.



Wuebben's compost turner in action.

A sample of the finished compost was taken to an Omaha laboratory to be analyzed with the following results:

Moisture	34.80%
Nitrogen (N)	0.80%
Phosphorous (P_2O_5)	0.62%
Potassium (K_2O)	1.17%
Organic Matter by Combustion	14.40%
pH	7.3
Total Organic Carbon	8.5 %
Carbon-Nitrogen Ratio	10.6

A tractor-powered, turning machine built by the Mehlaf Machine and Manufacturing Company of Freeman, South Dakota is used to turn compost at the rate of 400 to 500 tons per hour. This unit is used by Town and Country Park, Inc., in Sioux Falls, South Dakota, which processes sewage sludge, paunch manure, and stockyard pen wastes.

At the McGinley-Schilz feedlot in Brule, Nebraska, a specially designed machine aerates the windrowed manure. The compost is made under contract with the Colorado-Nebraska Compost Corporation owned by Jack E. Martin and Lester R. Kuhlman of Sterling, Colorado. The machine, known as the Scarab, was developed by Fletcher Sims of Canyon, Texas.

"About 20 tons of raw manure to the the acre would have to be applied to equal the benefits derived from two tons of compost," says Martin.

"It's turned our feedlot waste problem around. Instead of manure being a nuisance, it's a valuable asset," Schliz was quoted in an *Omaha World-Herald* article.

SOURCES OF COMPOSTING EQUIPMENT

The Cobey Composter

An Ohio feedlot has effectively used the Cobey Composter for processing animal wastes. This unit is a diesel-powered, self-propelled machine which straddles the windrows.

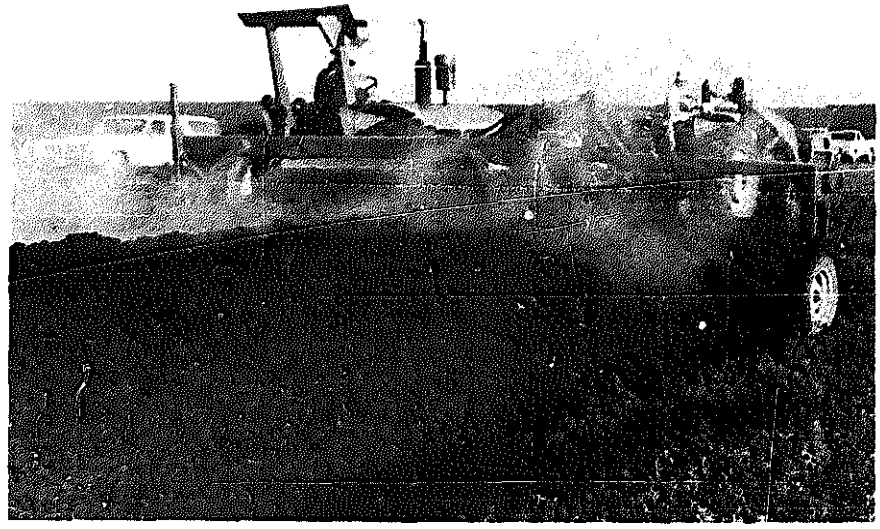
Manufactured by:
Eagle Crusher Co., Inc.
Rt. 2, Box 72
Galion, OH 44833

The Easy Over Composter

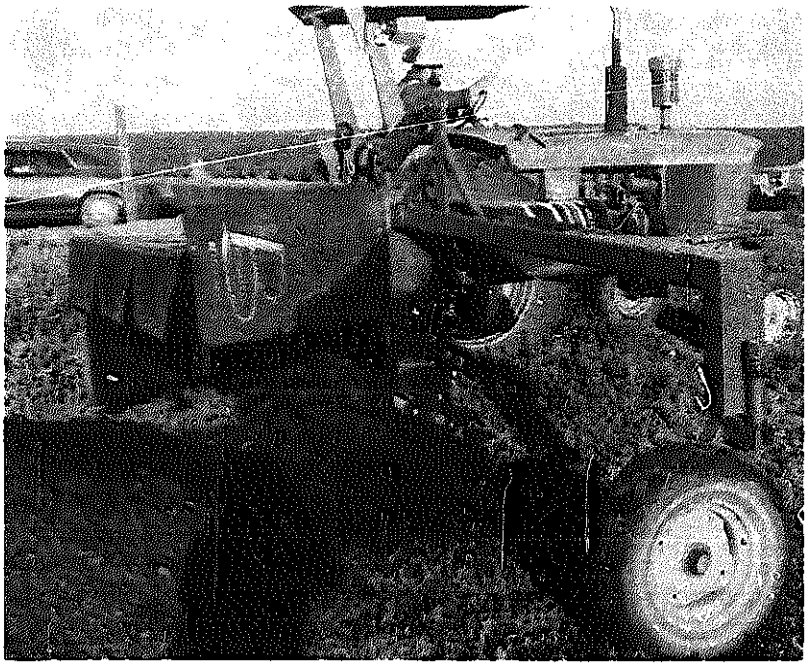
Another composting machine was developed by the late Elton Schaeffer of Menno, South Dakota "out of his own necessity." The machine has knives similar to those of a garden tiller, for lifting material up and back into the windrow. One-half of a compost windrow is taken with each pass of the machine, compared to the full windrow taken by larger machines. The operation, according to Schaeffer, is best accomplished with a hydrostatic-drive tractor for slower ground speed.

Schaeffer's machine now has the commercial name of Easy Over, and is distributed by:

General Corp.
322 S. 16th St.
Philadelphia, PA 19102



The compost turning machine used on the Elton Schaeffer farm at Menno, S.D., for composting manures brought to the farm from the local livestock sales barn.



Schaeffer's composting machine has tines similar to those of a garden tiller, to lift material up and back into the windrow.

Accelerator Compost Bin

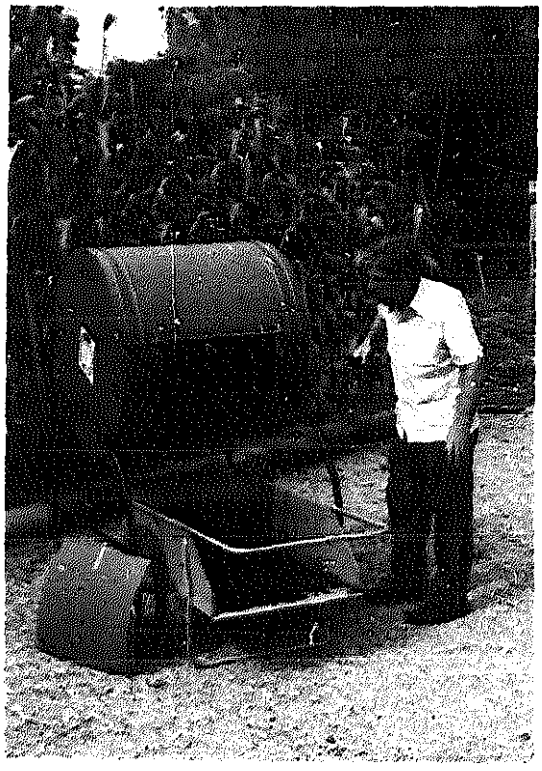
This 34 by 36 inch circular bin is made up of green, rigid, polyvinyl chloride interlocking and sliding panels. Waste is added through the top of the bin which has an inflatable cover to repel rain. Ventilating holes in the panels allow for ventilation while helping to hold in heat and insulate.

Rotocrop (U.S.A.) Inc.
P.O. Box 237, 58 Buttonwood St.
New Hope, PA 18938

Farnam
Dept. HB957, P.O. Box 12068
Omaha, NE 68112



Rotocrop Accelerator
Rotocrop (U.S.A.), Inc.



Compostumbler
Gardening Naturally

The Earthmaker and Compostumbler

This compost bin is arranged on a stand which allows the drum to be rolled in place. It holds more than 14 bushels of raw, organic waste and retains liquids.

Gardening Naturally
Rt. 102
Stockbridge, MA 01262

Garden Way Mfg. Co., Inc.
102nd St. & Ninth Ave.
Troy, NY 12180

Global Services, Inc.
P.O. Box 185-A, College Park
Lewisburg, PA 17837

Hand-Operated Mini-Composter

The steel blades of this composter grind vegetable refuse, bush clippings, vines, roots, and weeds up to a ⅜ inch diameter. Measuring 15 by 10½ by 8 inches, it clamps to any flat surface. The cast-iron cutter is manually operated.

Sears, Roebuck & Co.
Farm and Ranch Catalog

Cassaplanta
Dept. 123, 16129 Runnymede
VanNuys, CA 91406

SHREDDERS

Today's shredder-grinders are better than they've ever been—thanks largely to 20 years of organic gardening experience contributed and shared by a multitude of backyard growers. They're also more available in greater variety—some larger and more powerful, and some more compact—but all are designed to do a specific gardening job better.

The type of shredder you buy should depend on the kind of gardening operation you run, the size of your place, and the kind of organic materials you're going to feed through it. A good shredder will handle all kinds of garden wastes and residues without clogging, and it should be easy to move around, which means you can take the tool to the work—to the compost pile, the garden row, or the pile of wood chips that were dumped at the end of your driveway.

Today, there are two main types of shredders: the low center of gravity shredder-bagger with its big-mouth hopper, and the classic stand-up shredder-grinder designed to handle a greater volume and variety of materials.

Many combinations of accessories and functions are now available in one machine. The once-reluctant gas engine has been made a lot more dependable and easier to start. You can also find electric-powered shredders which are a lot quieter, easier to start, and also free of fumes. But they have to stay closer to the house and there is always the danger of playing around with electricity outdoors on the damp ground.

Many shredders, both low-profile baggers and the bigger grinders, are equipped with a chipping fixture which is usually a rotating knife that operates through a side slot and can



To keep a shredder from clogging, it's sometimes best to remove the screen, especially when shredding wet, soggy leaves.

handle branches up to two or even three inches thick. The MacKissic, Roto-Hoe and Lindig machines are three models with this feature.

Then there are the shredder accessories or attachments that fit onto a small riding tractor or a walking power unit that also functions as a rotary tiller, a mower, a chipper, a snowblower, or even a dozer blade.

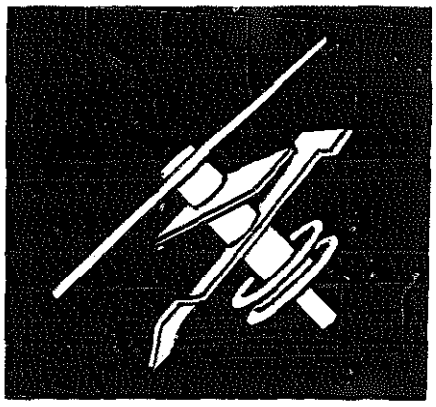
Overloading any machine will result in jamming and stalling it. This especially holds true for the shredder whose job it is to chop up fibrous, damp, or wet materials and then eject them through a screen or grid. We recommend working with as large a screen as possible—the 1¾ inch screen on the Lindig is excellent. Gilson, W-W, and Roto-Hoe offer a grating of rods or square roller bars which seem almost jam-proof. Another solution to the problem is the Winona's "wet mat rack" which encloses only half the shredding chamber.

If you're shredding with very wet, soggy, and rubbery leaves, here's a sure way to eliminate frustration and loss of time—remove the screen. Without it, the action of the cutters chops the leaves into a satisfactory aggregate which can be used either for compost or mulch. If you're working with a shredder-bagger, you may find it speeds up the task to remove the bag. You'll also find it's a good idea to deposit the aggregate immediately in the compost pile or the planting row.

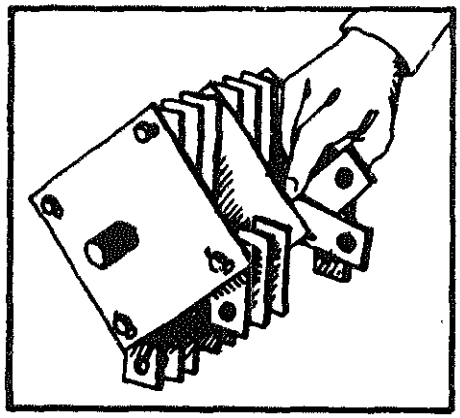
You may also find that a clutch, either centrifugal which depends upon the speed of the motor to actuate it, or one that is manually operated, helps avoid jams. This calls for alert operation of the machine, but it can save a lot of time spent clearing out the inside of your shredder.

Check the wheels on the shredders you are considering. They should have at least a pair, rugged and rubber-tired, and placed so they will comfortably and safely support the machine when you move it. Some of the larger models

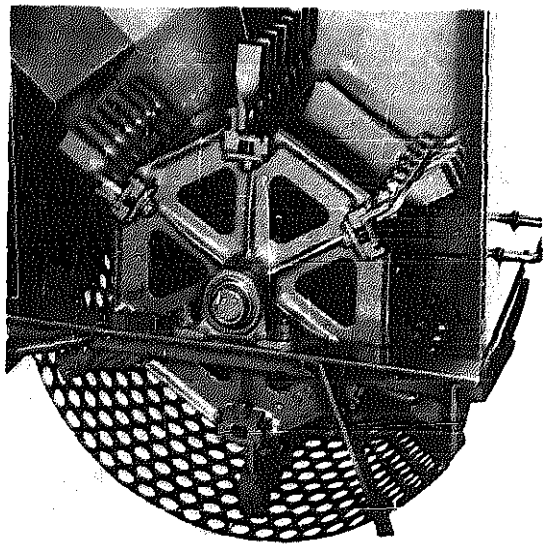
FOUR TYPES OF CUTTING MECHANISMS



Three-Cutter Rotary System

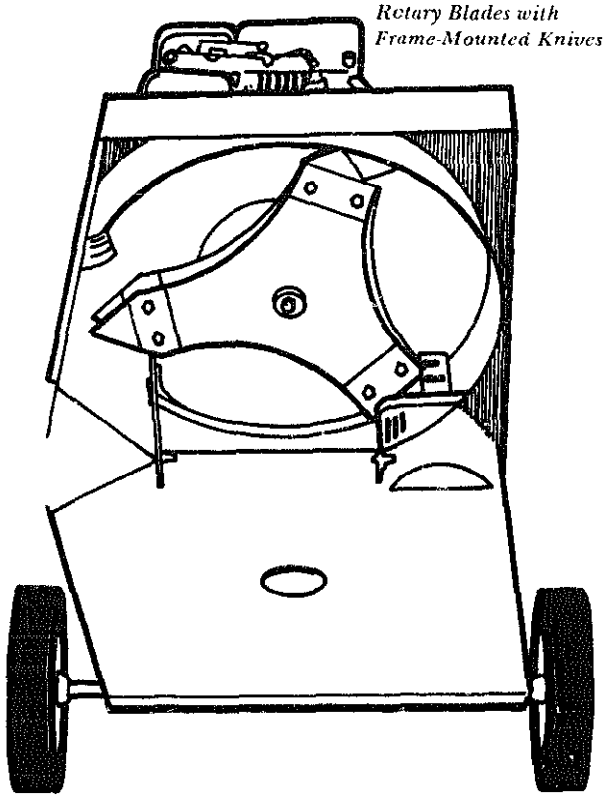


Hammer mill Unit



Rigidly Mounted Knives on Horizontal Shaft

Rotary Blades with Frame-Mounted Knives



Rotary blades that whirl through stationary knives mounted on the frame chop and fling the mass of particles out the side vent.

Another time-tested system is a series of knives rigidly mounted in a revolving horizontal shaft. The fabble plates and a screen tend to hold the material against the cutting action of the blades.

come with three wheels, and some with four. Make sure the machine you are thinking of buying handles easily and comfortably.

One of the most sensible gardening arrangements we've ever seen was at the Golden Acres Farm in lower Bucks County, Pennsylvania, where a double track of sturdy rails was erected over and along a series of compost bins. A king-sized shredder was mounted on the rails and traveled from bin to bin, depositing its aggregate as it went.

There are three or four basic systems for reducing and mixing your organic wastes. Hammer mill tempered steel flails revolve freely on a rotating shaft, and so have the ability to absorb shocks from hitting stones. There also seems to be a minimum of blockage in the mixing chamber caused by wet materials. Sets of hardened steel teeth or knives, fixed rigidly on a revolving shaft, work in combination with interior baffle plates and the bottom screen, which tend to keep the material in contact with the knives. The smaller shredder-bagger machines work with a series of two or three rotary blades similar to a lawn mower's. In some models, these whirling knives pass between stationary cutters that are part of the frame or chassis to achieve more complete cutting. The turbulence created by the rotary blades also whirls the aggregate out through the vent, which permits you to deposit it right where it is needed—either in the compost pile or in the planting row.

Any matter that is organic and compostable can be reduced to a workable aggregate or mass in your shredder. You will find that there is plenty of material on your home grounds to keep your shredder and you busy for a series of weekends, particularly in the late summer and fall. There are the weeds, the grass clippings, the crop residues, and the leaves. Add to these local benefits the contents of your garbage pail; it combines well with just about anything.

Next, there are the wood chips from the local road department, sawdust from the neighborhood lumberyard, and corncobs from the nearest feedmill (if you can get them ground). All of these varieties of celluiose are fine for mixing with the garbage. Working with unground corn cobs, though, can be tricky. The tough cobs have a habit of flying back up out of the hopper, right at your head. Some gardeners have reported that a thorough soaking (up to a week) of the cobs softens them and makes shredding easier.

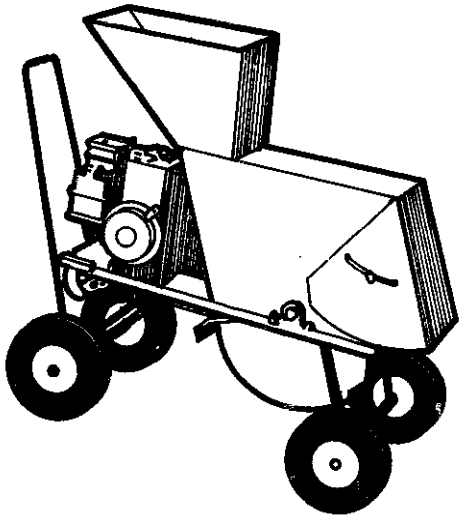
No garden chore is easier or pleasanter than shredding dry, autumn leaves. But if your leaves have wintered over and are tough, wet, and rubbery, feed them into the shredder in very small handfulls which are followed by dry sawdust, and again, be prepared to work without a screen.

TYPES OF SHREDDERS AVAILABLE

Think over your shredding needs carefully before you begin to shop for a machine. There are many different shredders on the market today, and rather than trying to list them all, we've decided to describe the basic types available and give some examples of each type. Keep in mind that models change from year to year, and be sure to investigate all the features of the models you're considering.

Large Shredder-Grinders

Most of the shredders in this group comprise the classics of the industry—the Amerind-MacKissic, Gilson, Lindig, and W-W. To them should be added the Royer, the Ariens, the Roto-Hoe, the Hahn-Eclipse and the Winona, all of which feature the larger machine in their wide-ranging lines.



Four-Wheel Shredder-Grinder

In general, these shredder-grinders are designed for the 1- to 5-acre place in the country, although you may be perfectly happy with one of these bigger machines on your suburban ½ acre. You'll find that they can handle a greater diversity of materials than the shredder-baggers and also a greater volume. And, thanks to their rugged framework and wheels, it's a lot easier than you would think to roll them out into the garden or up to the compost pile. It's also good to be able to report that shredders last for years with very minor repairs (made easily by the local dealer), so their cost can be amortized over quite a period.

Amerind-MacKissic Model 12-P is a 6 h.p. combination log chipper and shredder-grinder. In addition to handling conventional organic composting materials including corncobs, it reduces logs up to 3 inches to wood chips. Model 9-P is powered by a 4 or 5 h.p. engine and works through a series of 24 free-swinging knives. Power take-off units are available for many popular small estate tractors.

The 6 h.p. Gilson Chopper features nine, square, rotating cutter bars instead of a screen, which are ideal when you're grinding wet, soggy, fibrous materials. Cutting action comes from three sets of rotating double-edged knives—12 cutting surfaces. The gravity-feed hopper is king-sized—almost 17 by 17. The Chopper is belt-driven with an idler clutch.

The Lindig Concho is also available with an electric motor or a 5 or 7 h.p. engine. It offers a wide range of grinding screens from ¼ inch to 1¾ inch. A side-vented brush and wood chopper feed directly into the mixing chamber. The cutting and shredding unit is a series of free-swinging hammers. The steel frame is supported by three wheels, one up front which pivots plus two in the rear.

The 8 h.p. Roto-Hoe Cut'n Shred heavy-duty shredder-mulcher includes a side-feed which leads directly to three knives passing by a hardened block. We have used this feature to shred long, tough corn stalks, and found it did a good job. Built of 12-gauge steel, the frame sits on four wheels and has a long tow handle for easy mobility. The steel bar grate is wide-spaced to reduce jamming.

The Royer 8 is a specially designed machine whose endless shredding belt is lined with tempered steel cleats mounted in rows. Models 8, 10, and 12 are electric or gas powered with a capacity that ranges from 5 to 12 cubic yards per hour of soil, peat, and other organic materials. Many municipalities use the larger models for shredding prior to composting them. This is a well-made machine designed for blending, potting, and soil compost mixes.

In addition to a conventional screen, the W-W Model 62-G offers a grating of six rods and rollers for use when shredding wet materials.



The Royer Shredder

Powered by a 5 h.p. engine, it works through a series of tempered, hammer mill flails and can handle all conventional organic materials up to 1½ inch tree trimmings, small bones, phosphate rock, tin cans, and bottles. Optional grinding screens handle corn, wheat, or milo.

The Winona Model JR-AW comes mounted on four wheels, but Model JR-S can be mounted on a garden tractor or over the compost pit. The Winonas are electric or gas driven and have changeable racks including a wet mat rack for gummy materials which is a short screen covering only half the mixing chamber. Powered by a 2 h.p. engine, it works through a cutting unit comprising 16 hinged knives.

Lickity Chipster

The Chipster has an 8 h.p. gasoline-powered feed roll, a clutch to disengage the feed roll, a hammer mill-type rotor, shredding screen, and chip direction head. There are two wheels for convenience in moving, but the Chipster is not to be hauled as a trailer. The brush feed chute is 16 inches wide and 13 inches long with an opening to the rotor that permits feeding branches up to 2 inches in diameter. The self-feeding roller, located at the end of the chute, feeds the branch into the hammer mill-type rotor where it is shredded, screened, and dropped on the ground in front of the Chipster. If the dynamically balanced, hammer mill rotor should become overloaded, the powered feed roll will automatically stop until the overload has been cleared and then will automatically start again. Weight: 215 pounds.

Lickity Chipper Model PTO-5

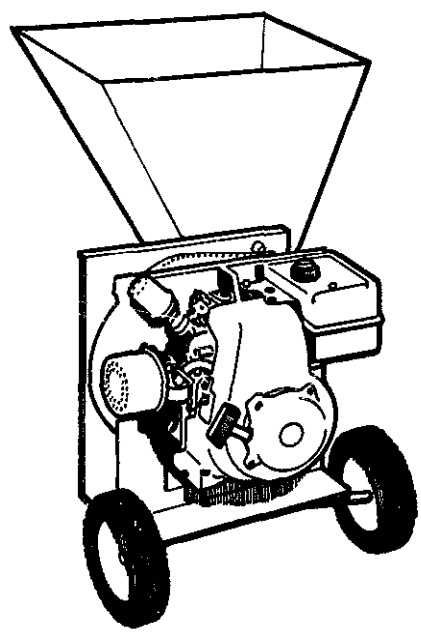
The Brush Chipper utilizes the power take-off of a tractor. The PTO model is equipped with wheels, tires, and tubes as standard equipment. It can be towed to the job at normal highway speeds behind any vehicle. The feed chute can be folded up and the blower discharge chute adjusted to make towing easier. The PTO model is equipped with a pin-type hitch coupler. The hammer mill rotor handles limbs up to 5 inches in diameter at a rate of 50 feet per minute.

A.M. Leonard & Son, Inc.
P.O. Box 816
Piqua, OH 45356

Diadem Brush Chipper

The Diadem Chipper will handle up to 3 inch diameter limbs. Brush self-feeds through the chipper and is converted into small chips in just a few seconds. Small brush can be processed in bundles at a time. It is constructed of heavy-duty plate steel with a 6 gauge (5 mm.) engine deck and a solid cylinder rotor. Imbedded in the solid rotor are two 0.4 inch thick cutting knives of specially hardened chrome vanadium steel. The wheeled Diadem is 30 inches wide; it can be taken anywhere for on-the-job brush disposal. All tires are fully pneumatic. You can choose from a three-point hitch PTO and 8, 10, and 12 h.p. models.

Vandermolen Corp.
119 Dorsa Ave.
Livingston, NJ 07039



Top-Vented Shredder-Bagger

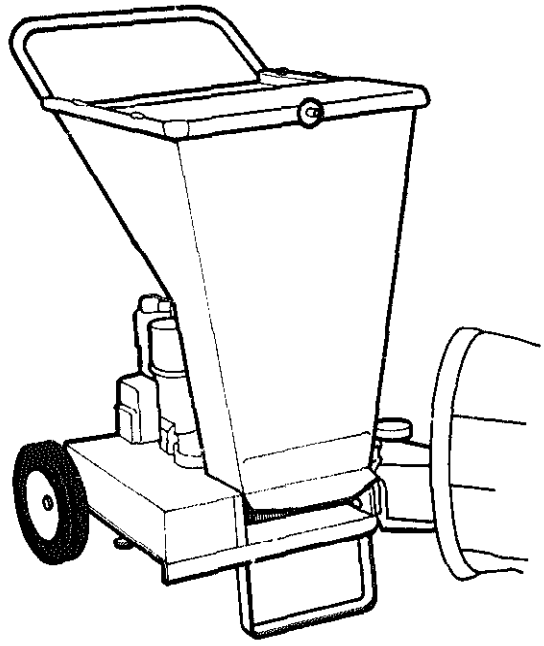
Top-Vented Shredder-Baggers

A top-vented, compact shredder-bagger will throw a stream of chopped aggregate into the garden or compost pile. The Hahn 3½ h.p. Mighty Compact and International Harvester 35P are in many ways identical. They are low-

profile, with wide-mouth, gravity-feed hoppers and a pair of wide-set, rubber-tired wheels for extra stability plus mobility. Both models feature hammer mill cutters and optional baggers.

Free-swinging, hardened steel hammers, a large feed hopper, and an adjustable discharge chute are built into the low center of gravity-feed McDonough Snapper. Model 30-S has been designed to handle leaves, bush trimmings, tree prunings up to ½ inch thick, and cornstalks. It is powered by a 3 h.p. engine with centrifugal clutch and belt drive.

A large (22 inches wide) drop chute for raking in leaves and other lawn debris plus a side-mounted chipping opening for branches are features of three top-vented shredder-baggers that are almost identical in design. They are the Columbia Model 654-4, the Jacobsen No. 50080, and the MTD No. 244-650. Powered by a 5 h.p. engine, each machine features a three-stage cutting action consisting of a single, flat reversible blade, nine flail knives, and four cutting fingers. In addition to the novel drop chute, these shredders each have extra-wide hoppers.



Bottom-Vented Shredder-Bagger

Bottom-Vented Shredder-Baggers

The Atlas, Cross, Kees, Roper, and Sensation models, while more or less identical in appearance—wide, low-set hoppers, each with a set of sturdy wheels, and engines mounted directly over the cutting units—are somewhat different in the features they offer.

The 5 h.p. Atlas does its cutting with three steel blades plus eight shear bars which permit it to cut wood up to 1 inch thick. Blade drive is direct from the engine. A poker rod has been built into the hopper for breaking up twigs and vines.

Cross shredders come in two models, the 3½ h.p. 4365, and the 5 h.p. 4650. Both shredders deposit chopped material in a bag and feature a sweep-in hopper that makes lawn cleanup easy. Power goes direct from the engines into the double-bladed rotary cutters.

The Kees Kom-Pak also has a rake-in hopper, an optional extra. Its steel cutting blades will handle wood up to 1 inch on the 5 h.p. model or ¾ inch for the 3½ h.p. Three bags are packed with each machine.

The 3½ h.p. Roper works with two high-speed blades to chop up leaves, twigs, and vines. It is worth noting that the accompanying Roper photos show it handling corncobs. The 6 h.p. model depends on triple cutting blades plus breaker bars in the chopping chamber. There is a fixed steel deflector on the discharge chute for directional control of the shredded matter. Bags are also available.

Power in the Sensation Eager Beaver goes directly from the engine to the double set of reversible blades without belts or chains; a safety clutch has been designed to protect the engine against shocks. The Eager Beaver dismantles easily for transport by car, thanks to large-diameter hand knobs.

The Sears 8 h.p. Super-Shredder resembles a rotary mower with its engine mounted directly over the three high-speed cutting blades. Shredded particles—leaves, vines, twigs, and garden debris—are vented at the bottom in a bag. The wide-mouthed but shallow hopper may be lowered for raking and sweeping in of lawn debris. Five bags are included.

The Toro comes in two models, 3½ and 5 h.p. Each features a big, slanting, gravity-feed

hopper with a pusher rod to handle the material. The engine sits directly over the cutter blades--two in the smaller model and three in the larger—which work in conjunction with the shredding bars at the bottom vent. An optional bagging kit is available.

SOURCES OF SHREDDERS

The following companies all market several different models of shredding machines:

Allis-Chalmers
Outdoors Leisure Products Div.
1126 S. 70th, P.O.B. 512
Milwaukee, WI 53201

Amerind-MacKissic
Box 111
Parker Ford, PA 19457

Ariens
111 Calumet & 655 W. Ryan St.
Brillion, WI 54110

Atlas Tool & Mfg. Co.
5151 Natural Bridge Ave.
St. Louis, MO 63115

Bolens Div. FMC Corp.
Urban/Suburban Power Equipment Div.
215 S. Park St.
Port Washington, WI 53074

Columbia
P.O. Box 2741, 5389 W. 130th St.
Cleveland, OH 44111

Gilson Brothers Mfg. Co.
Box 152
Plymouth, WI 53073

Hahn, Inc. Agricultural Products Div.
1625 N. Garvin St.
Evansville, IN 47717

International Harvester
401 N. Michigan Ave.
Chicago, IL 60611

Jacobsen Mfg. Co.
1721 Packard Ave.
Racine, WI 53403

F. D. Kees Mfg. Co.
Box 775, 700 Park Ave.
Beatrice, NB 68310

Lindig Mfg. Corp.
Box 111, 1877 W. County Rd. C
St. Paul, MN 55113

Magna American Corp.
Box 90, Hwy. 18
Raymond, MS 39150

McDonough Power Equipment, Inc.
Macon Rd.
McDonough, GA 30253

MTD Products, Inc.
Box 2741, 5389 W. 130th
Cleveland, OH 44111

Red Cross Mfg. Corp.
Box 111, 124 S. Oak
Bluffton, IN 46714

Roof Mfg. Co.
1011 W. Howard St.
Pontiac, IL 61764

Roper Sales Corp.
1905 W. Court St.
Kankakee, IL 60901

Roto-Hoe & Sprayer Co.
100 Auburn Rd., Rt. 87
Newbury, OH 44065

Royer Foundry & Machine Co.
158 Pringle St.
Kingston, PA 18704

Sears, Roebuck & Co.
925 S. Homan Ave.
Chicago, IL 60607

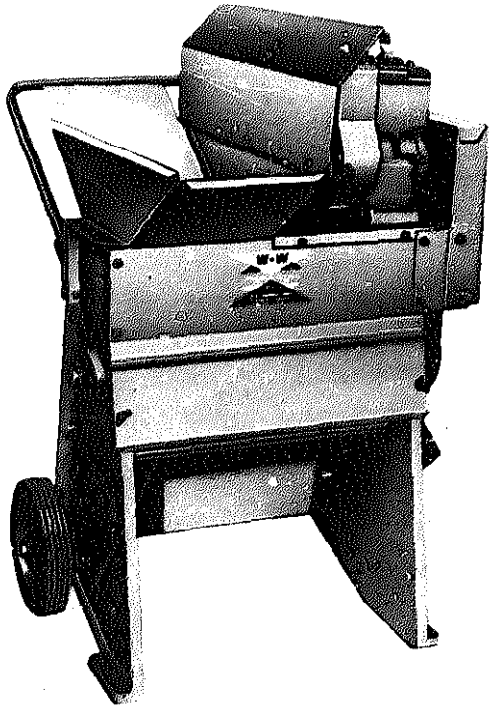
Toro Co.
8111 Lyndale Ave. S
Bloomington, MN 55420

Winona Attrition Mill
1009 W. Fifth St.
Winona, MN 55987

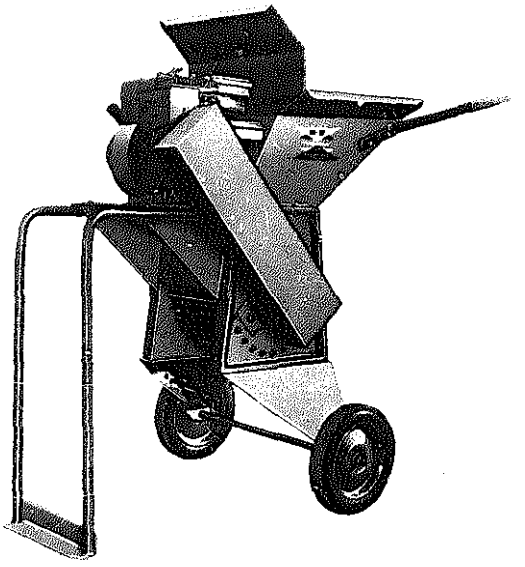
W-W Grinder Corp.
2957 N. Market St.
Wichita, KS 67219



W-W Grinder Model 5-20-4
W-W Grinder Corp.



W-W Grinder Model 2 + 62
W-W Grinder Corp.



W-W Grinder Economy Model A
W-W Grinder Corp.

MULCHING

Mulching is an important technique employed by the organic farmer for maintaining weed control, retaining of soil moisture, and increasing the amount of organic matter or humus present, hence improving the soil's tilth. Specially adapted lawn mowers are good for chopping grasses and weeds for mulch on a small scale. But we know of only one source of equipment for applying mulch on a serious scale.

SOURCES OF MULCHING EQUIPMENT

Rotary Mulching Mower

Manufactured by:
FMC Corp., Outdoor Power Equipment Div.
215 S. Park St.
Port Washington, WI 53074

Rotary Mulching Mower Conversion Plans

Plans for converting a lawn mower are available from:
Dorsay Poor Man's Catalog 3
240 Kinderkamack Rd.
Oradell, NJ 07649

Wayne Peters
Rt 2
Meadville, PA 16335

Rotary Mulching Mower Conversion Parts

The parts needed to convert a lawn mower are available from:
Better Life Enterprises, Inc.
1462 John St.
Whiting, IN 46394

Friday Straw Spreader

Originally designed for strawberry culture, the Friday Straw Spreader has the potential of being an important tool for the organic farm. Lack of mechanization for the mulch-spreading process has discouraged many organic farmers from utilizing mulch to its fullest potential. The 36 by 100 inch straw spreader mounts on a trailer or wagon and is powered by a crank start, 18 h.p., two-cycle engine (electric start optional). It can be adjusted to mulch on or between rows at a rate of about 1 acre per hour, governed by tractor speed. A hydraulic drive option utilizing a tractor hydraulic system or PTO pump can be provided. Shipping weight: 640 pounds.

Friday Tractor Co., Inc.
Hartford, MI 49057



The Friday Straw Spreader
Friday Tractor Co.

SLUDGE

While supplying the farmer with a source of plant food, applying organic wastes to the soil in the form of sludge offers a solution to the problem of finding an outlet for human waste products. Special equipment to pump, store, transport, and apply sludge to farm lands is in the early stages of development as the technique slowly gains credibility as a multipurpose solution to land fertility and waste disposal problems.

EQUIPMENT FOR INCORPORATING SEWAGE SLUDGE AND ANIMAL MANURES INTO THE SOIL

by Charles H. Reed

Professor of Agricultural Engineering, Rutgers University, New Brunswick, New Jersey

For centuries, man has applied animal manures and human sewage to the soil to improve crop production. The principal technique was to spread it on the land and then work it into the soil.

With the expanding population, depletion of our natural resources, and intolerable pollution of the atmosphere and hydrosphere, there is an urgent need for techniques to recycle biodegradable wastes into the upper horizon of the soil where they are degraded and utilized, resulting in a beneficial effect upon the environment.[1] Bohn and Cauthorn state, "In summary, compared to air and water, the soil has a vastly greater potential for waste disposal and transformation . . . and it has the capacity to absorb far more material than it can produce or than is added to it."[2]

The incorporation of wastes directly into the soil is superior to surface spreading because there are no odors, no opportunity for flies or other pests to feed or breed, no runoff or surface erosion of wastes, and the wastes are placed in the best possible media for immediate degradation to plant nutrients and utilization by plants. These techniques conform to the concept of land treatment as defined by Stevens et al.:[3]

> Land treatment is any of several methods of waste water treatment and sludge application which consider the qualities of land, waste water, and sludge in the design of facilities. Land treatment conveys the reciprocal, beneficial relationship between the land and the waste. Most such facilities are designed to produce valuable end products, such as green crops and pure effluent as a result of the treatment processes.
>
> Land treatment differs from land disposal, a term used to describe any method which applies sewage, raw or treated, to the earth; and land application, a term used by EPA [Environmental Protection Agency] to describe all methods of waste water disposal associated with the ground, that is, sewage farms, land treatment, septic systems, and underground disposal.

The design of an effective land treatment system and the selection of appropriate equipment necessitates the consideration of many factors, some of which are outlined below:

1. Wastes to be incorporated into soil:
   - Kind and previous treatments.
   - Physical and chemical properties, i.e., percent solids (wet basis) and rate of production (daily, weekly).
2. Storage available or required. Transportation.
   - Distance to sites.
   - Mode of.
3. Site characteristics or limitations.
   - Acreage.
   - Topography.
   - Existing vegetation.
   - Soil characteristics.
   - Ground water. (Depth, quality).
   - Location of human habitation. Distance. Prevailing wind.

4. Climatic limitations.
   - Temperature. Duration of frozen soil.
   - Rainfall. Seasonal, normal, and extreme variations.
   - End product desired. Crops to be raised, use of land, etc.

Irrigation of sewage sludge and effluent is receiving considerable attention at this time.[4,5] Only thin slurries with low-solid contents can be irrigated. Because of the high water content (more than 95 percent as it comes from the digesters), conveyance to disposal sites by pipeline may be the only practical transportation system. Storage structures at the sites will be required during periods of sub-freezing temperatures, frozen impervious soil, saturated soil, and other periods of shutdown. Unless thoroughly digested, surface applications of sewage sludge may generate odors and attract flies. Any surface applications are susceptible to surface runoff. There is a possibility of soil clogging and water-logging when sewage sludge is irrigated.[3,6] Also, there may be damage to foliage when large quantities of sludge are repeatedly sprinkled on plants. There will be large power requirements. The aerosol effect may limit high-pressure irrigation on some sites.

Irrigation of effluent containing only dissolved solids can be managed without many of the above disadvantages of sewage sludge, and may be considered for irrigation of crops or ground water recharge when needed. The limiting factor usually is the amount of water which can be added to the soil at different seasons of the year; that is, ice buildup or saturated soil.

Composting is an ancient technique of recycling biodegradable wastes. Modern techniques and equipment have been developed to compost balanced mixtures of biodegradable wastes including sewage sludge, animal manure, and solid wastes. See *Compost Science*, Vol. 13, No. 3, May-June 1972, for information on General Motors' Terex-Cobey Composter. These techniques are relatively expensive and may generate some localized odor. Well-cured compost can be spread on the land without attracting flies, is not as susceptible to surface runoff as is noncomposted waste, and is an excellent soil conditioner. An outstanding advantage of compost is that it can be readily stored in piles at low cost without nuisance until an appropriate time for application in the soil.

Land spreading is the most ancient method of utilizing both human and animal excreta. When plowed or disked immediately after application, it is an effective method of incorporating it into the soil. When large quantities are involved, this may be the most economical, but if not properly treated, it will not be the most sanitary technique.

The ridge-and-furrow technique might be considered a surface method of application unless covered immediately. The furrows can be made on the contour or slightly sloping to permit the water to filter into the soil. Ridge-and-furrows on the contour have been used experimentally at the New Jersey Agricultural Experiment Station as a low-cost winter storage. Aerobic conditions should be maintained in and at the bottom of the furrow.

Equipment has been developed which will incorporate wastes directly into the soil, either in one or two operations by Sub-Sod-Injection or Plow-Furrow-Cover.

Sub-Sod-Injection (SSI) equipment is available which will inject any slurries that will flow by gravity or under pressure through a six inch diameter hose two feet long. Animal manures with up to 20 percent solids and sewage sludge with up to 10 percent solids can be injected by gravity into the soil at the rate of 400 gallons per minute in a band up to two inches thick and 28 inches wide and from six to eight inches beneath the surface without turning over the soil. The injector has a standard category two, three-point hitch with a spring-trip release for passing over subsurface objects. It is comparable to a two-bottom plow in weight and durability. This equipment is not yet available commercially, but can be assembled from existing components.

The Plow-Furrow-Cover (PFC) method is the most adaptable of any of the previously mentioned techniques. Equipment is available, or can be assembled from manufactured components, to incorporate directly into the upper eight inches of the soil up to 300 tons per acre of biodegradable wastes, ranging from thin slurries (septic tank pumpouts) to semisolids (sewage cake). PFC leaves the soil plowed and

ready for disking and seeding. Two types of equipment will be described for PFC: one for 25 percent solids or less, and the other for greater than 25 percent solids.

One of the two recently developed pieces of equipment was assembled by Agway, Inc., of Syracuse, New York. The first one was used at the University of Connecticut in a research demonstration project to study the effect of incorporating septic tank pumpouts into the soil. In this project more than 100,000 gallons of slurry were incorporated into the soil in two months. The capacity of the tank is 800 gallons. A nine inch auger with ample hydraulic power from an auxiliary hydraulic pump on the tractor, and 12 inch as well as six inch valve openings will unload much heavier solids than would the previous prototypes. The highest limit of solids content which it will unload has not yet been determined. This equipment will not unload low-moisture sewage cake, semisolid animal manures with bedding, or caked poultry manure reinforced with feathers. A gooseneck tongue is built permanently into the tank to provide easy maneuverability of either a 16 inch single-bottom moldboard plow or a sub-sod-injector which is mounted on the three-point hitch of the tractor.

A second unit, constructed in 1973, is identical, except that it has a capacity of 1,500 gallons, a nine inch ribbon auger, and a slurry spreader on the rear. This unit has not yet been field-tested. The augers, valves, and spreader are powered by the hydraulic system on the tractor.

To plow-furrow-cover, a 16 inch single-bottom moldboard plow is mounted on the three-point hitch of a standard farm tractor. A slurry with up to 25 percent solids can be deposited into a six to eight inch deep plowed furrow. Immediately after deposition, and in the same operation, the plow covers the waste and opens the next furrow. With properly adjusted equipment, one and one-half to two inches of slurry can be completely covered. This is approximately 170 to 225 tons of slurry per acre. A well-formed furrow, 16 inches wide, seven to eight inches deep and 400 feet long with one and one-half inches of slurry, contains 500 gallons, or approximately two tons. PFC leaves the soil well plowed and ready for disking and seeding. The equipment has been designed to operate at three miles per hour and unload up to 200 gallons of slurry per minute. The axle of the trailer is adjustable so that the trailer is offset, permitting the right rear trailer wheel to travel in the newly formed clean furrow.

A combination transport and field unit was assembled by a tank on a four-wheel-drive, 1½-ton truck chassis with flotation tires. It is equipped with a hydraulic pump, controls, and a category two, three-point hitch. The tank has a capacity of 500 gallons. With a 12 inch ribbon auger in the bottom of the tank and a 12 inch diameter valve, semisolid animal manures with up to 30 percent solids, and sewage sludge with up to 20 percent solids have been unloaded. Because the hydraulic power is limited, the full performance capabilities of the 12 inch auger have not been determined. A spreader can be installed on the rear for land spreading.

A ridge-and-furrow opener can be mounted on the three-point hitch of the tractor or mounted on the tongue of the trailer. This consists of right-hand and left-hand moldboard plows bolted together on the same trip-release beam. The 12 inch opening in the center of the trailer tank permits a high-capacity application of semisolids into the furrow. Presently the furrows are closed or covered in a second operation.

The best equipment field-tested to date at the New Jersey Experiment Station, for unloading semisolids and cake with more than 25 percent solids, is a New Idea Flail Spreader. It can be adjusted for a wide range of surface applications, which are plowed under in a second operation. A conveyor similar to the one on a forage wagon is being adapted to this spreader to convey the waste into a furrow for PFC.

International Harvester sells an attachment to convert one of their heavy-duty manure spreaders into a self-unloading forage wagon. At this time it has not been demonstrated for unloading a gummy, sticky semisolid into a furrow.

There should be no difficulty to adapt either of these pieces of equipment to PFC for either one or two operations. Plans are underway at the New Jersey Agricultural Experiment Station to make these adaptations.

There are outstanding advantages in handling dewatered sludge with a solids content of 15 percent or greater.

1. As solids content increases, volume and weight decrease. For example, to inject one ton of solids in a 5 percent solution, 20 tons of slurry must be handled; for one ton of solids in a 15 percent solution, 6⅔ tons; and only 3⅓ tons if a semisolid with 30 percent solids, dry-weight basis.
2. It can be stored in contoured furrows or piles on well-drained sites to be incorporated into the soil when weather and soil conditions are optimum.
3. It can be transported in regular dump trucks without leakage on the highway.
4. Sludge with a solids content of 15 percent represents the minimum solids content which can be incorporated into the soil by PFC at the rate of 40 tons dry-weight equivalent per acre in one application: that is, 2.27 inches of depth in the furrow can be completely covered. Greater rates of application can be achieved in one operation if the sludge contains less moisture and more solids, and also because greater depths can be covered in the furrow. This rate of application represents the performance capabilities of the equipment and not necessarily the optimum or safe amount which the soil can tie up, degrade, and recycle. Smaller quantities can be applied.

In order to utilize the continuous output of sewage treatment plants, daily PFC applications at the desired annual rate may be made in contiguous strips or furrows, resulting in the entire plot receiving the total annual treatment. At any time when there is sufficient area of contiguous strips of plowed ground, it may be disked and seeded to the crop appropriate for that particular season. After some forage crops, that is, hybrid Bermuda grass, have been established, one or two applications can be made annually by PFC or SSI without replanting. For maximum recycling and utilization of nutrients from the sludge, crops should be raised on and harvested from the treated sites when mature or at the end of the period of their maximum assimilation. Numerous crop management plans and rotations are possible, depending upon the sites and the end product desired.

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4. Hinesly, Thomas D., and Sosewitz, Ben. "Digested Sludge Disposal on Crop Land." 41st Annual Convention Water Pollution Control Federation. Chicago, Illinois, Sept., 1968.
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SOURCES OF EQUIPMENT TO ADD ORGANIC MATERIAL TO THE SOIL

Big Wheels

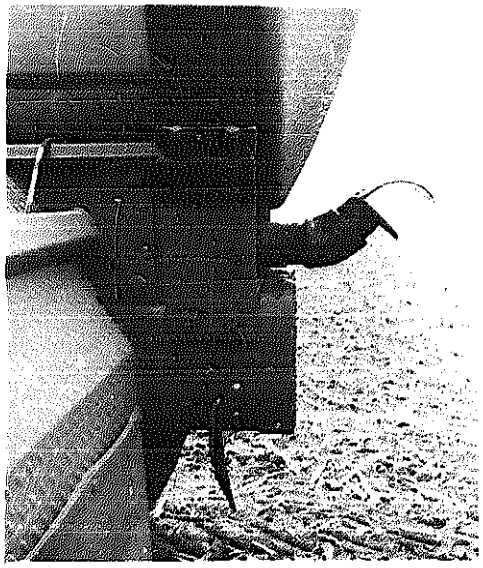
Big Wheels is a 1,600-gallon tank truck used for distributing sludge in either surface or subsurface applications. It is not built for road transport; it must be used in conjunction with sludge transport systems. For surface application, sludge is sprayed from the rear of the truck. For subsurface application, soil-slicing coulters precede chisel-plowing tines to cut a narrow path for application hoses. Injection is possible at adjustable depths usually between 6 and 9 inches. Furrow coverers are available but are usually unnecessary.

Big Wheels, Inc.
I-57 and Rt. 9
Paxton, IL 60957



Big Wheels—a coulter/chisel combination to dig the application channel.
Big Wheels, Inc.

Sludge leaving the outlet under pressure hits the deflecting cover . . .

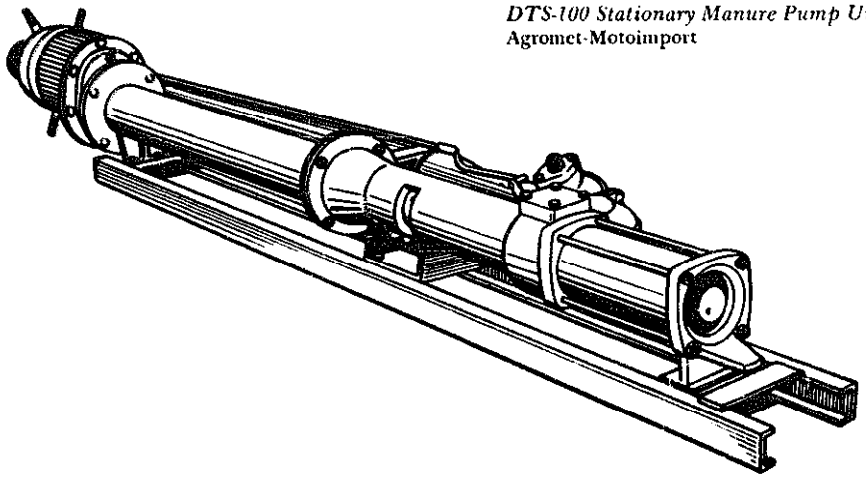


. . . and sprays a wide pattern behind the truck for surface application.



DTS-100 Stationary Manure Pump Unit

This is a stationary unit comprising the HSP-100 electrically driven screw pump as well as the delivery pipe with three-way valve and mixing nozzle. It is mounted on a supporting rail made of channel sections which should be fixed permanently at the place of pump installation. It is possible to mix the manure in tanks, to pump it over from initial tanks to main tanks, to pump over from the tank to the water cars, and to deliver from the tank directly to the sprinkling system, when the area to be sprinkled is nearby the farm. The unit can be used with even very dense liquids for which no other pump can find application. The stationary unit is best suited for large pumping jobs.



DTS-100 Stationary Manure Pump Unit
Agromet-Motoimport

Specifications:	
Delivery of pump	—40 meters over 3 hours
Pressure of pump	—100 m H 0
Speed of pump	—560 rpm
Electric motor	—type SZJVe-64 b
Total weight	—897 kilograms
Depth of tank	—3.5 meters

It will deliver at a rate of 40 cubic meters per hour.

Agromet-Motoimport
Foreign Trade Enterprise
00-950 Warszawa, ul.
Przemyslowa 26, Poland

-10- Woodlot and Orchard Management

TOOLS FOR THE WOODLOT*

by Jim Ritchie

For most homestead timbering purposes, you will need to make a small investment in tools: a lightweight chain saw or bow saw, an axe, at least two steel wedges for splitting logs and rails, and a sledge to drive the wedges. You may prefer a splitting hammer: a sledge with a hammer face on one side and a wedge-shaped splitting blade on the other; once you get the hang of using it, this tool can speed up timber chores.

You may also find a use for a machete, brush hook, grub hoe, mattock, power circular saw, and bucksaw. Other, more specialized tools and equipment are occasionally called in for particular jobs around the homestead, but unless you use a specialized piece of equipment enough to justify the investment, you may want to borrow or rent, rather than buy.



Handling wood with a peavy.

* Reprinted from *Trees for the Yard, Orchard, and Woodlot,* edited by Roger B. Yepsen, Jr. Rodale Press, 1976.

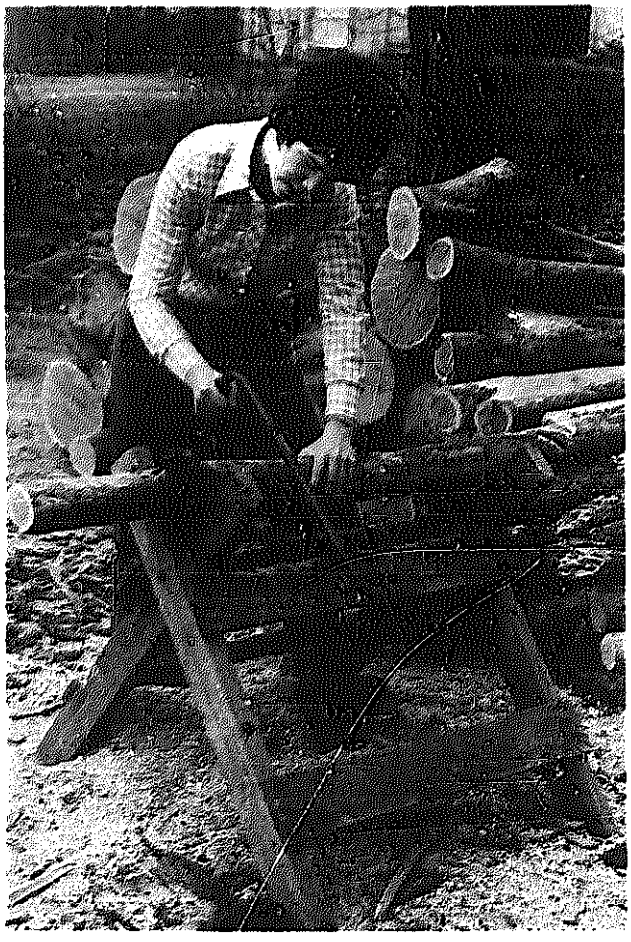
All woodcutting tools should be kept sharp and out of the rain. Well-maintained equipment is not only easier to work with, but safer as well. A sledge or axe that is loose on the handle is a hazard both to the operator and to fellow workers or bystanders. A dull axe blade may bounce or glance off the log and into a human limb.

SAWS

For most homestead work a lightweight chain saw with a 14 or 16 inch cutter bar is sufficient. You can buy heavier, more powerful models if you need to do a lot of heavy work. But by notching and undercutting with smaller saws, you can fell trees up to three feet in diameter. If you've never operated a chain saw, try out two or three different models and sizes. Also, consider the availability of parts and service before you buy.

Chain saws aren't for everybody. Many people object to the cash investment, the stink or the noise, or the gas and oil consumed. You may prefer to work with a crosscut saw—either the two-man variety (if you have a steady helper) or a one-man saw. The rhythmic sound of a crosscut has a soothing quality, something that certainly cannot be said of a chain saw.

Two-man saws are typically six to seven feet long and have cutting teeth alternated with drag teeth to remove sawdust from the saw kerf (or slot). These saws are made of high-quality steel and are too limber and springy for handy operation by one man. However, it is possible to use a two-man saw by



The proper stance at a sawhorse.

yourself if you remove the handle from one end and support that end of the saw with a slender, limber stick cut to just the right length. Poke the stick into the ground at the midpoint of the saw's travel, on the opposite side of the log (or tree) from the sawyer, and tie the upper end of the stick to the saw where the handle was removed. The stick then supports the saw so the blade doesn't flop and wobble. It's not as handy as a sawing partner, but it works.

One-man crosscut saws are shorter, about five feet in length, and are made of heavier metal than two-man crosscuts. They are not as likely to buckle when pushed and pulled from one end.

Because of the chain saws's great popularity, manual crosscut saws have all but disappeared from some areas—even in regions of heavy timbering. And, as with most steel products, prices have climbed rapidly in the past few years. To find a used saw, check classified ads in local newspapers and visit a few farm sales. (Often you can also find reasonably priced axes, sledges, wedges, files, and other timber equipment at these sales.)

For lighter work, a bow saw or bucksaw is more convenient than a crosscut. These have two- or three-foot saw blades stretched in a metal or wooden frame, hacksaw fashion. They're ideal for bucking off cordwood cuts, limbing, and other light timber work and can be used to fell smaller trees. They also come in handy for pruning fruit and ornamentals.

With all saws, power or manual, the condition of the cutting teeth has a big influence on the condition of the sawyer at the end of a day's work. There's an art to filing and setting saw teeth, and no two timbermen file a saw the same way. You'll need a good, clean file—about a number ten bastard flat file for crosscut saws. Chainsaw chains have teeth of various sizes, so you'll need to buy a file to fit your particular saw. Bow saw blades can be easily replaced.

You'll also need gauges to show the length and set of the saw teeth. (Turn the saw teeth up and sight lengthwise along the blade or chain; the angle of the cutting teeth from the plane of the saw blade is called the set.) For cutting fibrous wood, such as green oak or hickory, you'll need to set a greater angle than normal into the saw's teeth.



Older circular saws, like this PTO-run model, often appear at farm sales and auctions.

For clearing brush and small trees from land to be cultivated, a wheel-mounted circular power saw can come in handy, particularly if you're clearing large areas. These saws are fast and effective in cutting top growth. Some models are self-propelled but shouldn't be used on steep slopes.

AXES

A good single- or double-bitted axe is a necessary homestead tool. Keep the blade sharp on the job with a small pocket whetstone.

Some woodsmen prefer to use a double-bitted axe, with one blade honed sharp and the other allowed to dull slightly; the dull blade serves well for grubbing out roots and cutting off sprouts below ground level, while the sharp blade is never used for such rough work.

Leaving one blade slightly dulled gives a measure of protection when chopping among limbs that might catch the axe and divert your swing. If the axe glances into your leg or foot (an occurrence to be avoided at all costs) at least you have an even chance that the dull blade will make contact.

HOMESTEAD USES OF TIMBER

A homestead woodlot can provide shelter, fuel, tools, equipment, and outbuildings—depending on the size of the woods, the kind of trees grown, and the imagination and skill of the landowner.

FIREWOOD

Trees are most often cut for burning. Even if you cut timber for other purposes, you'll find that much of your firewood supply—perhaps all of it—can come from the leftover portions of the harvested trees.

Wood varies in heating value with species used and the degree of seasoning. Wood that has been allowed to air-dry for a year or more after cutting has a moisture content of 20 to 25 percent and will burn better and produce more heat per unit of wood than freshly cut, green wood. Also, dried wood does not deposit as much creosote on flue walls, lessening the chance of a chimney fire.

The best firewood burns steadily but not too quickly, produces a lot of heat for the amount of wood used, and burns cleanly with little creosote deposit and little ash. The table below gives the heat equivalents of the most common firewood species (based on air-dried wood) as compared with fuel oil. The heat values are given in millions of Btu's (British thermal unit—the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit) per cord of wood.

Softwoods generally make poor firewood. They burn too quickly, produce relatively little heat, and often give off unpleasant odors. For example, air-dried red pine has but 12.8 million Btu's per cord as compared with 24 million Btu's per cord of white oak.

HEAT EQUIVALENTS OF WOOD, BY SPECIES

Wood (1 standard cord)	Available heat of 1 cord of wood (Btu's)	No. 2 fuel oil (gallons)
Hickory, shagbark	24,600,000	251
Locust, black	*24,600,000*	*251*
Ironwood (hardhack)	24,100,000	246
Apple	23,877,000	244
Elm, rock	23,488,000	240
Hickory or butternut	23,477,000	240
Oak, white	22,700,000	232
Beech, American	21,800,000	222
Oak, red	*21,300,000*	*217*
Maple, sugar	21,300,000	217
Birch, yellow	21,300,000	217
Ash, white	20,000,000	204
Walnut, black	19,500,000	198
Birch, white	18,900,000	193
Cherry, black	18,770,000	191
Tamarack (Eastern larch)	18,650,000	190
Maple, red	18,600,000	190

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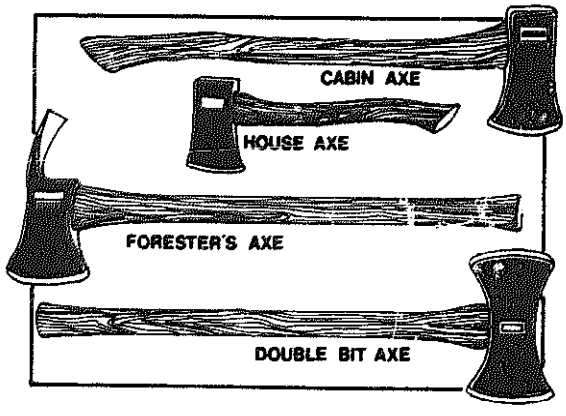
HEAT EQUIVALENTS OF WOOD, BY SPECIES

Wood (1 standard cord)	Available heat of 1 cord of wood (Btu's)	No. 2 fuel oil (gallons)
Ash, green	18,360,000	187
Pine, pitch	17,970,000	183
Sycamore, American	17,950,000	183
Ash, black	17,300,000	177
Elm, American	17,200,000	176
Maple, silver	17,000,000	173
Spruce, red	13,632,000	139
Hemlock	13,500,000	138
Willow, black	13,206,000	135
Pine, red	12,765,000	130
Aspen (poplar)	12,500,000	128
Pine, white	12,022,000	123
Basswood	11,700,000	119
Fir, balsam	11,282,000	115

WHAT TO LOOK FOR IN AN AXE

by Ken Bernsohn

1) Head weight. This varies from a pound and a half on some Hudson Bay or Tomahawk models to over six pounds. Traditional wisdom suggests that the heavier the head, the more effective the axe. There's more weight behind the cutting edge, so gravity can help it on its way. The theory proves out when felling trees, splitting wood, or chopping logs so they'll fit your fireplace. Too light an axe can make you feel ineffective. But that heavy head can also be a hindrance when you're limbing trees, grubbing out saplings, or just turning dead branches into firewood for a campfire. For these uses a 2½ pound head works better, letting you control exactly how the head lands while it's on the way down.



The other obvious aspect of weight is that gravity can help your axe down only after you've hoisted it up against gravity. A six pound axe is a quick way, at first, to hurt yourself more than you hurt the log. If you're going to be using an axe for a living, or intend to build a log home, you might consider one. If you're using your axe, like most of us, as an adjunct to a chain saw, or for both limbing and felling, you'll find a four pound head is far more comfortable to live with, providing enough wallop to go through a log without harming you and enough control to make limbing easy.

2) Head shape. Double-bitted axes reek with the romance of the North Woods. They're also practical because one edge can be razor-sharp for fine work, while the other can be blunter and stand an occasional nick when used for splitting logs or grubbing. However, you do not want one when starting out with an axe. I live in an area where the main industry is logging, and almost every home has an axe, yet I've seen only

three experts use double-edged blades. The droop-nosed Tomahawk is even less popular because of its excessively curved face and bantam weight.

If you're interested only in felling, a very narrow blade is right. An axe intended for a bit of felling, splitting, limbing, and grubbing will probably be best with an edge about 4½ inches from top to bottom.

3) Steel. Some axes have steel so soft you'll have to almost continually sharpen them, touching up in the midst of each tree or log. Others are so tough that you need a grindstone to sharpen them, pausing every minute or less to plunge the axe head into cold water to make sure it keeps its temper. The ideal axe head is between these extremes, soft enough to let you manicure it in the field when it gets a little dull, hard enough that this won't be necessary too often. If your choice is between the two extremes, get the soft one and take along a file and stone.

4) Handle length and style. A handle less than two feet long will cramp you, forcing you to prop up whatever you're chopping on a high platform. You'll also find that the short handle means less power behind each swing. A straight handle makes sense only on a double-bitted axe.

These are the only sure things about length and style. When people made their own handles, each man worked out for himself what was best for him. I find an axe with a 2½ foot handle is usable, and a model that's a yard long is best. But that's probably influenced by the fact that I'm six feet, five inches tall. I also would prefer to have more of a ball end on the bottom of the handle (the foot) to help stop any tendency to slip or twist. But that's me, not you. To find out what suits you, you've got to take each axe off the rack, hold it across your body for feel, and make a few practice swings. Sure, it's a good way to feel a little foolish, swinging at invisible trees in a crowded store on a Saturday. But it's better to feel a little foolish on a Saturday than feel a lot foolish when you go back to get a different axe a few Saturdays later.

HOW TO SHARPEN YOUR AXE

The odds are that when you buy your axe it will need sharpening. Step 1: Immobilize the head by putting it in a padded vise. If you're outdoors or don't run a workshop, you have two options. One is to lean the head against a stump or something else far more solid and stable than your knee. This is the traditional way, with the blade up, which I used until Gary Champagne saw me using it. He pointed out that, since you file into the edge of the axe, there was nothing to stop me from running my fingers into the edge. Gary's method is to lay the axe flat on a stump or table with just a quarter-inch of edge showing over the side. Now when you file into the blade, your fingers will hit the side of the stump or table before the steel, thanks to the angle you'll be filing at. Step 2: Use a full-size metal file, preferably with a wooden handle,



When sharpening the axe, use a full-size metal file. Make sure you do not sharpen the edge only, but work back one inch.

working back from the cutting edge. Make sure you do not just sharpen the edge itself, or you'll end up with a wide V that gets wider with time, making your axe less and less effective. Instead, sharpen a full inch back from the edge so the taper is gradual. Wear gloves. Step 3: Finish off with a whetstone. Trying to do the whole job with a stone will wear your patience thin long before the edge gets that way.

HOW TO CHOP DOWN A TREE

Put your axe in a safe place and walk around the tree, studying it. Are there any large branches that will cause problems? How thick is the tree? If it's more than 1½ feet in diameter, chopping with an axe will be a workout. Consider borrowing or renting a chain saw if you have several large trees to be removed. Does the tree lean? Most do. The easiest way to fell a tree is to chop so it'll follow its natural bent. If the tree shouldn't fall in the direction it's leaning, you'll have to do extra work.

The best way to change the direction of the fall is to tie a weight to a rope and throw it toward the top of the tree, snagging some branches before the rope falls back to earth. Bring the weighted end around the tree, so you're holding both ends with the tree in the middle of the loop. (This will take a few tries; if the tree is firmly rooted and easy to climb, like most apple trees, consider using your feet instead of your pitching arm to get the rope in place.) Now tie one end of the rope around the base of another tree that's roughly in the direction you want your tree to fall.

Haul on the rope, and you'll find it's easy to sway the tree. Have someone else tie your end onto another tree base so the three trees and the rope make a V, with the point being the one you're cutting. If it's hard to sway the tree, or if the tree's rough, have a few friends help. Do *not* tie the second rope to a truck and use it to pull the treetop! The tree will probably either snap in the middle or pull out by the roots, falling on the truck or on you.

Another, less sure way is recommended only for trees with moderate lean when you want to change the angle of fall less than 45 degrees. Let's assume the tree is leaning south. Chop your first notch, the one that determines the fall, on the west. Make the second cut, the one that actually topples the tree, from the northeast. The tree will twist as you make this cut and fall more toward the west. How much more will depend, of course, on how much it was leaning in the first place. This is faster than the rope trick, but far less precise, as our phone and power companies will attest.

When you go back for your axe, pick it up so your hand is on the handle right against the base of the head. Now you can control it, which you can't if you carry it over your shoulder or swing it by your side. This way there can't be a problem if your dog rushes up or if you trip.

Remember: an axe is more dangerous than a gun. You can unload a gun, but an axe, even one with a leather sheath, is always ready to do damage.

That's why you should look about carefully when you get to where you'll stand while cutting. If there's anything around that might deflect the blade, like low bushes or low branches, clear away the obstruction. Make sure children, advice-giving adults, and animals are well beyond the place where the tree might hit if it falls where you don't want it to. Stand at a right angle to the side where you'll make your first cut, with the axe going in on the east if you want the tree to fall that way (unless you're correcting a twist).

With your right hand at the base of the head, thumb against the metal, left hand at the bottom of the handle, make your first swing, letting your right hand slide as you swing. It should go straight in, waist high. Your second swing goes in higher, cutting down toward the first. How much higher? It depends on how thick the tree is. If you make your blows right on top of each other, as though driving in a nail, your axe will soon get stuck.

By making a wide kerf, as the notch is called, this problem is eliminated. And even when the kerf is six inches wide, a slight twist with your right hand as the axe lands will pop out a broad, flat chip each time to clear a space clean down to your bottom cut. Alternating blows, straight in and down, continue until you're about two-thirds of the way through. This will again vary, depending on the tree. Do not go more than three-fourths of the way

through. You may have a winner of a tree that leans a lot and needs only a one-third cut before the shifting of the top or the sound of a creak tells you you've done more than enough.

Listening for the sounds of the tree and glancing up to see what the top is doing every few swings will help you pace yourself, instead of chopping as though each minute costs you money. High speed only costs you energy.

On a wide tree, work your way across the full diameter, cutting a chip from the far side, then one from the near, then as many as necessary in between to keep your line straight.

When you feel "just a couple more whacks will be enough," stop, walk to the opposite side, looking up while doing so, and start your second cut. On a narrow (six-inch-wide) tree this can be about four inches higher. On one a foot in diameter it should be about eight inches higher. Unless you're cutting sequoias, 1½ feet would be maximum.

The tree will fall before you chop all the way through. So watch and listen as you chop. Pause, lean on the tree a little, long before you've cut enough, just to see if the tree agrees with your judgment.

HOW TO LIMB A TREE AND LOG IT

When the tree falls, a lot of it will still be in the air. Stand with the tree between you and the first branches you'll be cutting, working from the bottom to the top.

Some people do both felling and limbing holding the axe like a baseball bat. I don't like this method for felling, but for limbing, the baseball or golf club grip works fine. Cut away from your body, working only on the far side of the tree. Then go around to the other side and limb the one you were standing on first.

If you're working with a large tree, you'll reach a point where branches hold the trunk five feet or so into the air. To log into approximate eight-foot lengths, go back to the base.

About eight feet from the bottom step onto the trunk, plant your feet at least 2½ feet apart. Have someone hand you the axe and chop from the side, with the axe going between your legs that are safely out of the way. If you had stayed on the ground chopping from the top down, the tree would eventually bend, making further chopping impossible. Make a deep notch on one side, then turn around and work from the other side. Once again, you should stop before chopping through. Standing with one foot on each half of the trunk when the ends break and the log shifts is not a good idea. After you're two-thirds of the way through, you can continue from the ground with the wide kerfs you've cut, giving your axe room even when the trunk bends at the hinge you've been making. When the tree has had a few of these eight-foot lengths cut out, you'll find the limbs are now easier to reach, and the eight-foot sections you've cut can be moved around to let you get at any branches holding up trunk sections.

HOW TO SPLIT A LOG INTO FIREWOOD

Wait until you feel tense and frustrated. Then go out and prop up an eight-footer across another, or even across a few so that a two-foot section sticks over the end. Cut it off. A bow saw is the best hand tool for this, since it'll leave you a flat end that's important later. If using an axe, make that first cut straight in and chop toward it, gradually turning the log so each piece you cut has one flat end. Then move the log you cut farther along and do it again and again, until you have a stack of two-foot lengths.

In cutting hardwoods—trees that once had leaves—you'll find the going a lot easier if you cut while the logs are still green. This isn't as important with softwoods, but again it makes the work a little less.

To split the wood, look for cracks in the log. Stand one up on a stump and drive your axe into the biggest crack. Some people pick up the axe and log together at this point. But the log will twist on the axe. The log may fall off the axe onto you. The log may come back with your axe and keep going, as though propelled with a throwing stick on your backswing. Instead, I pry the axe loose, reset the log, and whack into the same spot. Three or four whacks and you'll have most logs in half. Depending on the diameter, you may want to split it again, and possibly again.

If the log is as big around as the potbelly stove, the method you've just read doesn't always work. You may find it best to drive a wedge (which can be a genuine wedge or a battered axe

head you picked up at a junk shop) into the top of the log, using a sledge. Using the back of your good axe for this can stop it from being your good axe, so use the sledge. Then lay the log on its side and use your axe to drive toward the crack the wedge started.

HOW TO DAISY A LOG

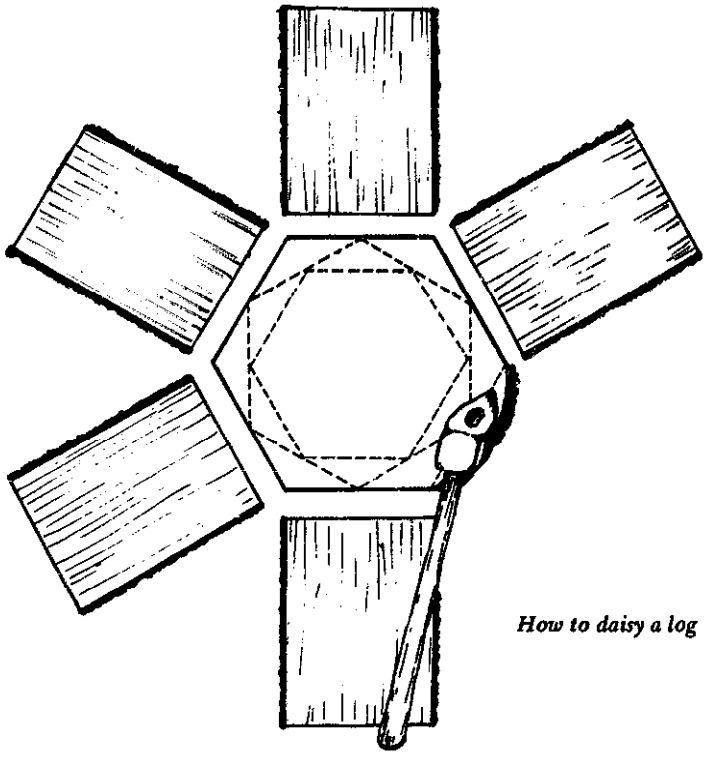
by Lewis Weeks

When a piece of wood is too large to be halved or quartered with an axe, daisying is called for. To daisy a big hunk of wood efficiently is a pleasing experience both mechanically and aesthetically. As you move around the chunk, backing away from the last cut, you split off a three- or four-inch deep piece from the outside of the chunk. If your cuts are clean, each piece will fall away from the center of the chunk and lie flat on the ground. When a complete circuit has been made, there will be the petals of your daisy, facing out from the center. Pile the petals, and go around again and again until you have reduced your big piece to half or a quarter of its original size.

STORING YOUR AXE

When you are done using your axe, take a hefty swing at your chopping block and leave the axe imbedded, assuming you'll return the next day. If you won't be chopping for a few days, bring the axe inside, wipe it off with an oily rag, and put it away. Storing it behind a bookcase or workbench will make sure it doesn't cause problems.

This sounds as though using an axe is a lot of work. It is, especially at first, when you forget to wear gloves and raise blisters. But it's satisfying work that you will enjoy in several ways. It removes you from the majority of folks who rely on store-bought logs to fuel their stoves, since in many areas the state forest services have areas open for those who want to cut their own firewood. It gives you a justified sense of self-sufficiency as you gain skill. And it makes your evening fire a matter of pride, something far more enjoyable than it would otherwise be.



How to daisy a log

WOODLOT EQUIPMENT

The following manufacturers and suppliers deal in forestry equipment of all types and sizes. If you are looking for peaveys, cant hooks, grapples, axes, shears, or machetes, try the following:

Snow and Nealley

Manufacturers of "Our Best" line of forged tools for loggers and lumbermen (pulp hooks, cant dogs, pickaroons, etc.) along with some real specialties—bush hooks, grab hooks, and tell-tale rods.

Snow and Nealley
155 Perry Rd.
Bangor, ME 04401

Glen-Bel

The Glen-Bel catalog features a full line of hand tools for woods work, including shears (Wiss, Belknap, Cyclone, and Blue Grass), pruning saws, bow saws, pike poles, timber carriers, and all types of axes and hatchets.

Glen-Bel Enterprises
Rt. 5
Crossville, TN 38555

Tree-Trimming Tools

Stanley offers a good variety of hydraulically operated tree-trimming tools, from pole chain saws and tree pruners to circular saws and weed eaters.

Stanley Hydraulic Tools
13770 S.E. Ambler Rd.
Clackmas, OR 97015

Friend

The Friend catalog features a full line of hand and power pruning equipment—shears, anvil pruners, lopping shears, pole tree pruners, telescoping saws, and more.

Friend Mfg. Co.
Gasport, NY 14067

Bartlett

A comprehensive line of tree-trimming equipment is offered by this company.

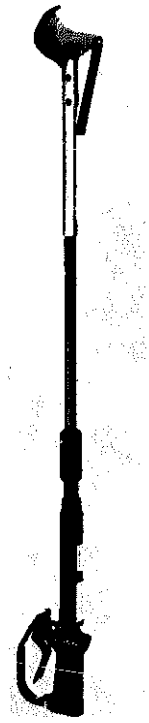
Bartlett Mfg. Co.
3003 E. Grand Blvd.
Detroit, MI 48202

Sandvik

This firm offers a complete line of pruning saws, bow saws, and hand saws.

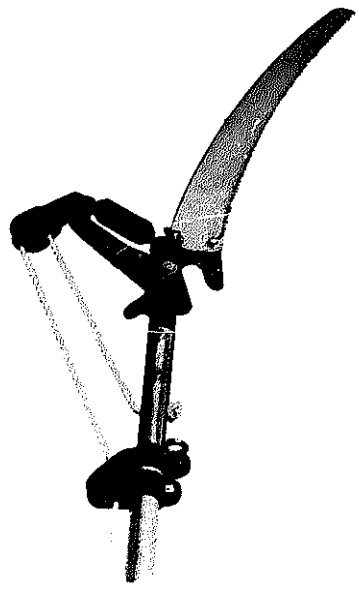
Sandvik, Inc.
Saws & Tools Division
1702 Nevins Rd.
Fair Lawn, NJ 07410

An Assortment of Woodlot Tools



Stanley Agricultural Power Pruner (3, 4, and 5 foot lengths)
Stanley Hydraulic Tools

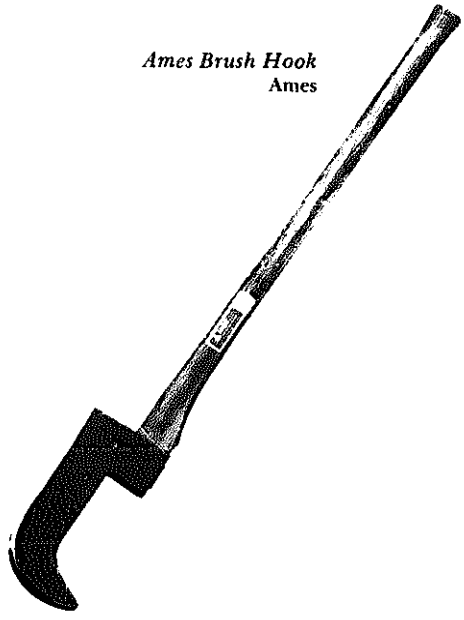
Ames Pole Tree Trimmer
Ames

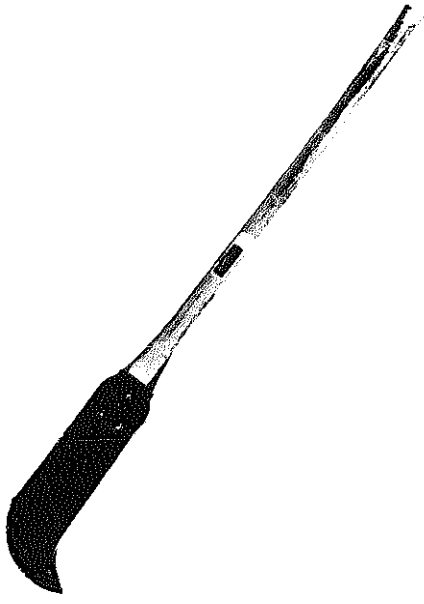




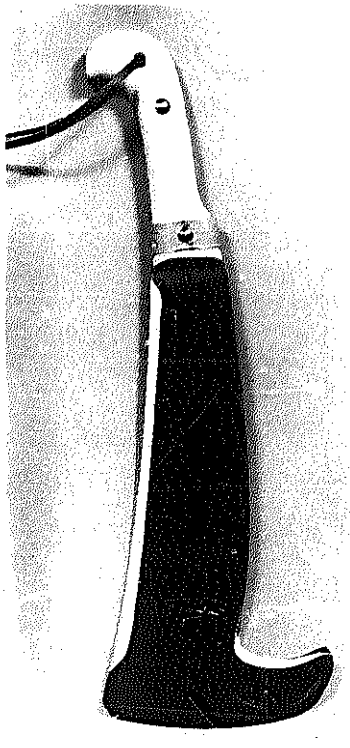
Stanley Agricultural Long-Reach Circular Saw (overall length, 5 feet)
Stanley Hydraulic Tools

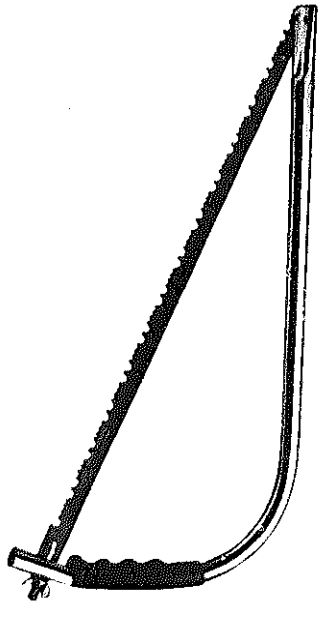
Ames Brush Hook
Ames





Ames Ditch Bank Blade
Ames





Ames Bow Saw
Ames

Woodsman's Pal Brush-Clearing Knife. Note the two cutting surfaces.
Oley Tooling, Inc.

Survival Equipment Co.

This company manufactures an especially helpful lightweight, machete-type tool for efficient land-clearing with minimum fatigue. It features a concave design with a blunt toe at the end of the cutting edge to minimize the risk of injury from a missed stroke.

Woodsman's Pal Brush-Clearing Knife
Survival Equipment Co.
Oley Tooling, Inc.
Oley, PA 19547

Cumberland

Pruning knives and saws, lopping shears, and budding and grafting knives are among the forestry-related equipment of various manufacturers listed in the Cumberland catalog.

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

Leonard

This firm markets pole saws, pruner poles and pruning saws, timber carriers, peaveys, cant hooks and other logging tools.

A. M. Leonard & Son, Inc.
Piqua, OH 45356

Anchor Tools

William Day at Anchor makes and sells some of the more primitive woodworking tools like adzes, broadaxes, and drawknives.

Anchor Tools & Woodstoves
618 N.W. Davis
Portland, OR 97209

Dixie

A complete line of logging equipment, replacement parts, specialty forgings, and wood turnings is available here.

Dixie Industries, Inc.
1210 Greenwood Ave.
Chattanooga, TN 37404

Meadows

The Meadows catalog contains 500 pages of forestry and engineering equipment of every description. They carry many specialty items found nowhere else.

Ben Meadows Co.
3589 Broad St.
Atlanta, GA 30366

Forestry Suppliers

They are among the world's largest forestry supply houses. If you can't find it in the FSI catalog, you might be in trouble. A sampling: skidding grapples, bowsaws, crosscut saws, pruning saws, timber carriers, pike poles, tree climbing gear, horticultural knives, and much more.

Forestry Suppliers, Inc.
205 W. Rankin St., Box 8397
Jackson, MS 39204

A German Supplier

Wolf and Bankert produce high-quality cutlery, including machetes and land-clearing knives for every purpose.

Wolf & Bankert
Werkzeug Fabrik
563 Remschied, W. Germany

Fiskars

Manufacturers of a wide range of quality equipment for professional foresters in Europe and North America. A few highlights in the Fiskars catalog are their log hooks, timber stacking claw, skidding grapple, and forest hoe for planting bare-rooted and rolled plants.

Fiskars
Mannerheimintie 14A
Helsinki, Finland

Belknap

This distributor carries a good variety of wood-handling tools, as well as pruners, shears, and machetes.

Belknap, Inc.
P.O. Box 28
Louisville, KY 40201

WHAT TO LOOK FOR IN A CHAIN SAW

The first important rule in chain saw shopping is: look for a nationally known brand and don't spend too much money. You can buy a good saw for under $150 for work around the homestead or farm woodlot. It should last for years if cared for properly.

You'll find models where the chain runs when the motor does, and models that have a centrifugal clutch so you can run the motor without running the cutting chain. The latter kind provides a measure of safety.

Some models have self-oiling features, which keep the chain oiled automatically. They don't seem to offer much advantage over the hand operated oilers that squirt the chain when you push the plunger.

Some manufacturers make a saw with a rotating tip set in the end of the blade. These are supposed to reduce wear on the chain, and this feature is a plus, although not necessary to good operation. You'll also find models with self-sharpeners, but these tend to wear the chain down too fast and require an unusual chain design that may not be as efficient as the standard chain.

Try starting the saw you intend to buy. If it is hard to start in the showroom, it'll probably be hard to start in the woodlot.

An 18-inch blade should be fully adequate for use on the homestead or farm, so don't pay extra for blade length you can't use.

Chain saws have to be sharpened precisely. If you do it yourself, invest a couple of dollars for a saw-sharpening guide. Otherwise, entrust the job to a professional or a friend who does craftsmanlike sharpening. The chain must also be kept at the right tension, and you'll need a wrench and screwdriver for this.

Remember to keep the gas-oil mixture balanced. Too lean on the oil means a burned-out engine. Too heavy on the oil means a fouled motor and a hard start.

Be very careful of secondhand saws. You're more than likely to be buying someone's problem. Since a properly kept new saw lasts for many years, the initial investment is very often worth it.

And finally, use some discretion with the saw. A chain saw is noisy and dirty and doesn't offer the rhythmic harmony of hand sawing or felling trees with an axe. However, it can increase your sawing power ten times over what you can do by hand, and the little bit of gasoline involved can be put to hard, practical use freeing you from what could be a back-breaking chore.

HANDLING YOUR CHAIN SAW

by Walter Hall

If, like me, you are a lover of solitude, chances are you'll pass much of your time in the woods alone. That is why it's important to carry a whistle, a good loud one. If you ever get pinned by a tree or cut yourself, you can give it a good blast. Along with the whistle, when you're preparing to go out for a load of logs, take along all the tools you're likely to need. Take extra fuel and all the extra maintenance parts, such as air filters, spark plugs, and an extra chain and sprocket. Start with a sharp chain and a clean saw. After every hour of work, stop and service your saw. This means you fill the fuel and oil tanks, clean or change the air filter, touch up the chain, and wipe off the saw. If you discover or suspect any problem with your chain saw, stop working until the problem is diagnosed and corrected.

Take frequent breaks. Listen to the living trees around you and don't cut them off for firewood. They are sentient creatures—the tongues of the wind and the earth.

FELLING SMALL TREES

There are two basic cutting operations involved with felling any tree. These operations may be altered or complicated by the size of the tree, the lay of the land, and the required direction of fall. These two operations, the notch, or directional cut, and the felling out, or back cut, are done somewhat differently with a chain saw than with an axe. The notch determines



Notching a small tree.
Allis-Chalmers

and controls the direction of the tree's fall. The notch and the back cut must always be made so as to form a hinge of uncut wood. As the tree falls, it pivots on this hinge, breaking it.

First, you make a notch. The basic notch for a small tree is made with two cuts. Make the upper of the two cuts first, to avoid pinching the bar. It's a lot of work to dig a saw out of a tree with the tree's full weight pressing down on it.

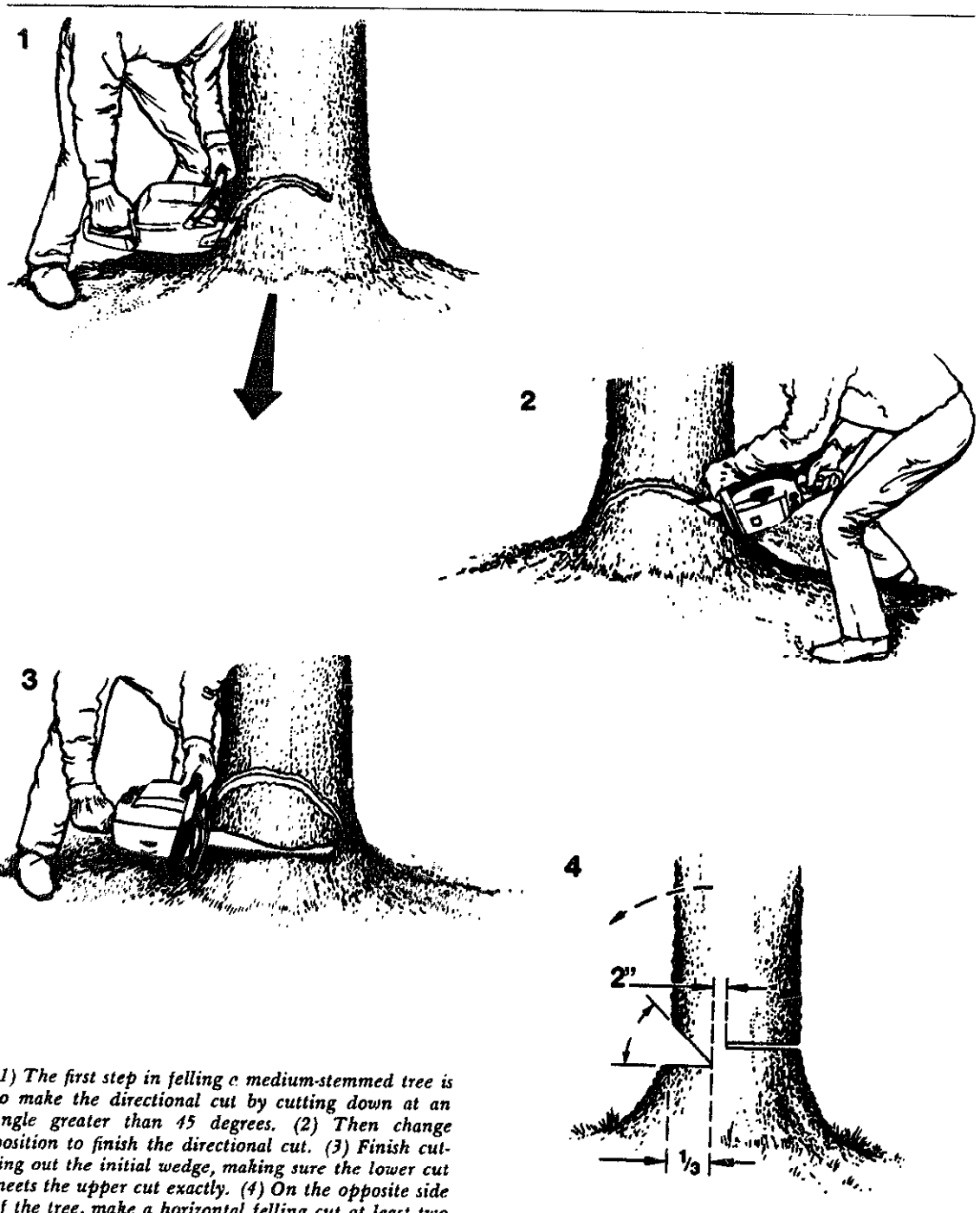
Move to one side of the tree, facing the planned direction of the fall. Aim across the top of your saw, along your front handle or falling sights, at exactly the place where you want the tree to fall. This will correctly line up your guide bar with the trunk of the tree.

Now make the upper cut of your notch, cutting down at an angle. Cut at least a third of the way into the tree, but not as much as halfway. Then make the lower cut. With a small, straight tree on level ground, make this second cut straight in to meet the first. Make the cut horizontal, and cut clear back to remove the whole notch. The hinge will be formed by uncut wood at least two inches thick between the back of the notch end and the felling cut.

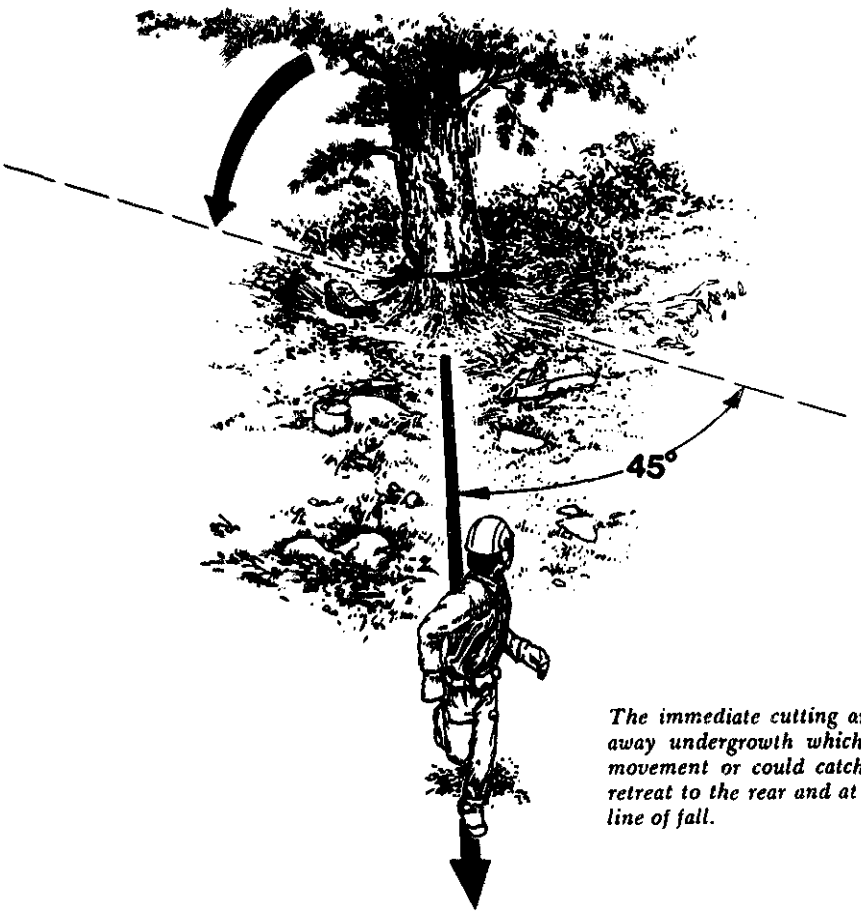
Now go behind the tree and make another horizontal cut, two inches or more above the lower, or horizontal cut of the notch. It is extremely important not to make this second cut so it will meet the horizontal notch cut. It must be an inch or two higher. It is also important not to cut through the hinge wood.

When enough of your felling cut is complete, stop your saw and leave it in the cut. Insert a wedge in the cut to prevent it from closing on your saw and to help control the direction of the fall toward the notch. Then start your saw again and continue until the cut is complete, leaving only the hinge. At this time the tree should fall. If not, give it a little push, or use a felling lever. As the tree starts to move, leave your saw on the ground and retreat quickly along your planned escape route (see page 443). Remember that the butt end of the tree may kick backwards as the tree falls and that unseen dead branches may fall straight down, or in any direction, as the tree topples. Take no chances. Retreat quickly and without hesitation along your escape route.

That's how you cut down a tree when its



(1) The first step in felling a medium-stemmed tree is to make the directional cut by cutting down at an angle greater than 45 degrees. (2) Then change position to finish the directional cut. (3) Finish cutting out the initial wedge, making sure the lower cut meets the upper cut exactly. (4) On the opposite side of the tree, make a horizontal felling cut at least two inches above the lower (horizontal) cut of the notch. When only a narrow hinge remains (about one-tenth of the tree's diameter) you're ready to insert your wedges or felling lever and topple the tree.



The immediate cutting area is prepared by cleaning away undergrowth which could interfere with free movement or could catch fire. Plan a path or safe retreat to the rear and at a 45-degree diagonal to the line of fall.

diameter is less than the length of your guide bar. But we're also going to be cutting down trees equal to or larger than the length of our guide bars. These situations require a specific sequence of cuts.

FELLING LARGER TREES

To cut a tree with a diameter larger than the length of your guide bar but not twice its size, proceed as follows: Make a notch, as before. Each cut of the notch may require as many as two cuts to complete. You can do this by making one half of the upper notch cut on one side and then moving to the other side of the tree to complete the upper notch cut. Do the same with the horizontal notch cut.

After the notch is formed, make a plunge cut about an inch or two above the notch and on the opposite side of the wood that will form the hinge. Start the plunge cut with the underside of the tip. When the bar has cut a few inches into the tree, straighten the saw to begin sawing straight inward from the tip of the bar.

When your plunge cut is about halfway into the tree and about twice the width of your guide bar, proceed to make the felling cut by sawing around the tree. Make a pivot with the tip of the guide bar in the center of the tree. Be careful not to cut into the hinge wood, and be sure to insert your wedge or felling lever in plenty of time to force the tree in the right direction. If you use a felling lever, be careful not to hit it with your saw. If you use wedges, be sure to use plastic ones, or make your own from wood.

To fell a tree with a diameter equal to or greater than twice the length of your guide bar, only one additional cut is necessary. This time the additional cut is in the notching operation

and, in effect, cuts the hinge itself in half.

Make the notch, as before. Now make a plunge cut at the back of the notch, right in the center of the tree. The plunge cut should be at least twice the width of the guide bar.

Cutting a plunge at the back of the notch in this manner actually creates two hinges. Make another plunge cut at one side of the trunk and on the felling-cut side of the hinge. The cut meets the plunge cut that comes through the center of the notch. Continue the felling cut by sawing around the tree with the tip of the bar in the center of the trunk. Place your wedges or felling lever in plenty of time, and be careful not to cut through the hinge.

Note that if you fell a large tree on a slope, you should make the bottom notch cut at an upward angle. This provides more control during a longer fall.

ORGANIZED FELLING

We're going out into the woods to fell a good number of beetle-killed Ponderosa pine trees. The trees are standing dead and are grouped pretty much together, on the side of a slope facing the road but a good distance away.

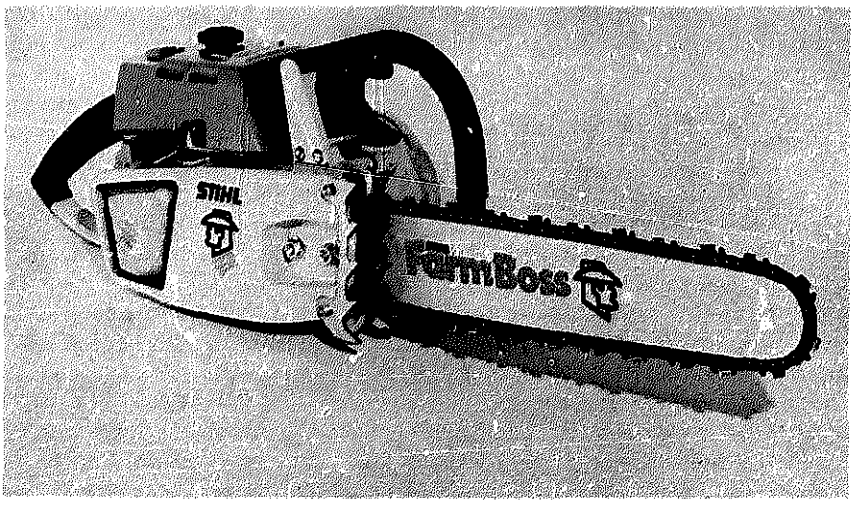
We want to move the trees as little as possible, and we want to fell them so they'll be easy to limb and buck into loading-sized logs. We'll start cutting at the edge of the trees closest to the road, and we'll use one or more of the trees as a workbench for limbing all the trees that come later.

For a workbench, fell a tree diagonally across the center of your start of operation. Then fell tree number one so that it falls across the workbench. This lifts the trunk up off the ground and makes limbing and bucking easier. Limb the whole tree, from trunk to top. It helps to mark the tree for bucking while you're limbing it. With the tree limbed, it's easy to roll or see-saw the tree across the workbench to one side. Then you can buck it into lengths to be rolled downhill to the road. This method quickly leads to piles of bucked logs, ready for loading.

When you follow an organized felling procedure like this, save the side trees for last. You can use your accumulated piles of timber for workbenches for these trees.

Demanding as it is, working with a chain saw is incomplete exercise. It may add some strength to your arms, but will do little for your overall physical condition. My own formula for unwinding after a long session with the chain saw is to devote some time to meditation and yoga. It's the best cure, for me, though a walk in the woods works almost as well.

Sleeping under the trees on a warm afternoon is another ideal way to counter the negative effects of running a gasoline-powered engine. Sitting by a river dipping your toes isn't bad, either. When working in the woods, the natural woodsperson takes long and frequent breaks. It's the only way to remember who you are, where you fit, and why you're there. For safety's



Manufacturers recognize the many uses a chain saw can have on a farm or homestead.
Stihl, Inc.

sake, you should work with a partner whenever you can. For nature's sake, you should each take your breaks in solitude.

ATTACHMENTS FOR A CHAIN SAW

Individuals who haven't had a great deal of experience with chain saws may feel that tree felling and trimming may be the limit of a saw's usefulness. However, with the number of attachments becoming available, the power unit on a chain saw can be a very valuable addition to a tool collection.

The Stihl 08's, a 14-pound unit driven by a single cylinder, two-cycle gasoline engine, is capable of running a cut-off saw, a brush cutter, and one- and two-man earth augers. On many models, power heads can drive hedge trimmers, lumber-making attachments, mills, and drills.

Not all chain saws will drive all the possible attachments, so carefully check into accessories before buying a chain saw. A single power unit running several tools can be much less expensive than buying each tool separately for your woodlot.

CHAIN SAW MANUFACTURERS

Advanced Engine Products
(Savage & Forester Chain Saws)
3340 Emery St.
Los Angeles, CA 90023

Allis-Chalmers
Box 512
Milwaukee, WI 53201

Alpina S.P.A.
31015 Conegliano
S. Vendemiano (TV) Italy

Alpina S.P.A.
Mr. H. J. Hutchinson
Box 313
Trail, British Columbia, Canada

Danarm Chain Saws
Yankee Clipper Trading Post
2405 Boston Post Rd.
Guilford, CT 06437

John Deere & Co.
Moline, IL 61265

Dolmar North American
947 W. Foothill Blvd.
Monrovia, CA 91016

Echo Chain Saws
3240 Commercial Ave.
Northbrook, IL 60062

Frontier Chain Saws
P.O. Box 491, Waneta Road
Trail, British Columbia, Canada

Homelite Division of Textron, Inc.
P.O. Box 7047
Charlotte, NC 28217

Husqvarna
151 New World Way
South Plainfield, NJ 07080

Jobu Chain Saws
Elkem-Spigerverket a/s
1441 Drobak Norway

Jonsereds Chain Saws
Tilton Equipment Co.
4612 N. Chatsworth
St. Paul, MN 55112

McCulloch Corp.
5400 Alla Rd.
Los Angeles, CA 90066

Massey Ferguson
1901 Bell Ave.
Des Moines, IA 50315

Oleo-Mac (Olympic) Chain Saws
Scotsco, Inc.
9180 SE 74th Ave.
Portland, OR 97206

Partner Industries of America, Inc.
255 E. Industry Ave.
Frankfort, IL 69423

AB Partner
S-431 20 Molndal 1,
Sweden

Pioneer Chain Saws
7605 Cushman Dr., P.O. Box 82409
Lincoln, NB 68501

Poulan Chain Saws
Beaird-Poulan Div., Emerson Electric Co.
5020 Flournoy/Lucas Rd.
Shreveport, LA 71109

Remington Chain Saws, Desa Industries
25000 S. Western Ave.
Park Forest, IL 60466

Skil Corp.
5033 Elston Ave.
Chicago, IL 60630

Solo Motors, Inc.
5100 Chestnut Ave.
Newport News, VA 23605

Stanley Hydraulic Tools
13770 S.E. Ambler Rd.
Clackamas, OR 97015

Stihl, Inc.
P.O. Box 5514
Virginia Beach, VA 23455

Stihl Motorsagen
D-7050 Waiblingen
West Germany

SOURCES OF CHAIN SAW ACCESSORIES

Atom

They are manufacturers of chain saw drill attachments.

Atom Industries
15 Reynolds St.
Balmain, N.S.W., Australia 2041

Bailey

Mail-order suppliers of chain saws, tools, and accessories, they also have a logger's job service.

Bailey's
P.O. Box 550
Laytonville, CA 95454

Bell

Formerly known as Nielson, they are manufacturers of home and shop electric saw chain grinders, carb-cutter attachments, and chain saw related machines.

Bell Industries, Saw and Machine Div.
3390 W. 11th Ave., P.O. Box 2510
Eugene, OR 97402

Brookstone

This company markets a chain saw sharpening jig.

Brookstone's Hard-to-Find Tools
125 Vose Rd.
Petersborough, NH 03458

Carlton

They are manufacturers of a saw chain.

Carlton Co., Saw Chain Division
3901 S.E. Naef Rd.
Portland, OR 97222

Defiance

They are manufacturers of the Little Logger chain saw accessory.

The Defiance Co.
Hancock, MI 48830

Davis

They are manufacturers of chain saw testing equipment for mechanics.

Perry Davis Equipment
21353 Endsley Ave.
Rocky River, OH 44116

Granberg

They manufacture chain saw tools, and assorted accessories; ripping chain, Alaskan Mill, Break-N-Mend, and File-N-Joint.

Granberg Industries, Inc.
200 S. Garrard Blvd.
Richmond, CA 94804

Haddon

They are manufacturers of chain saw accessories; the Lumber/Maker attachment.

Haddon Tool
4719 W. Route 120
McHenry, IL 60050

Heli-Coil

They manufacture thread repair kits.

Heli-Coil Products
Shelter Rock Lane
Danbury, CT 06810

Kwik-Way

They manufacture machines and tools for small-engine mechanics.

Kwik-Way Mfg. Co.
500 Fifty-seventh St.
Marion, IA 52302

Lewis

This firm makes chain saw winch attachments.

Fred A. Lewis Co.
40 Belknap Rd.
Medford, OR 97501

Loctite

They are manufacturers of thread-locking compounds.

Loctite Corp.
705 N. Mountain Rd.
Newington, CT 06111

Merc-O-Tronic

They manufacture chain saw ignition-testing equipment.

Merc-O-Tronic Instruments
215 Branch St.
Almont, MI 48003

Omark

This company markets saw chain, tools, and accessories.

Oregon Saw Chain Div., Omark Industries
9701 S.E. McLoughlin Blvd.
Portland, OR 97222

Permatex

They manufacture gasket sealers.

Permatex Co., Inc.
P.O. Box 1350
West Palm Beach, FL 33402

Phelon

They manufacture ignition parts for chain saws.

R.E. Phelon Co.
East Longmeadow, MA 01028

Sandvik

They are manufacturers of forestry tools, guide bars, chain saw tools and accessories. "Swedish Forestry Method."

Sandvik, Inc.
1702 Nevins Rd.
Fair Lawn, NJ 07410

Sears

You'll find accessories, a lumber maker attachment, and sharpeners in the catalog.

Sears, Roebuck & Co.
Farm and Ranch Catalog

Skil Corp.

This company manufactures professional air and electric impact wrenches, and shop tools for chain saw mechanics.

Skil Corp.
5033 Elston Ave.
Chicago, IL 60630

Spencer

They manufacture logger's tape, felling and bucking wedges, and chain saw and logger accessories.

Spencer Production Co.
P.O. Box 224
Pullman, WA 99163

U.S. General Supply

This is a large mail-order tool supply company, with various chain saw accessories for sale.

U.S. General Supply
100 General Place
Jericho, NY 11753

V.I.P.

They manufacture portable, electric, saw chain grinders.

V.I.P. Industries
300 S. Richardson Rd.
Ashland, VA 23005

Walbro

This firm manufactures chain saw carburetors.

Walbro Corp.
Cass City, MI 48726

Whitney

This is another large, well-known, mail-order tool supply company.

J.C. Whitney Co.
1917-19 Archer Ave., P.O. Box 8410
Chicago, IL 60680

Windsor

They manufacture saw chain, guide bars (Timber King), tools, and accessories.

Windsor Machine Co.
3147 Thunderbird Crescent
Burnaby, British Columbia, Canada

Zip Penn

They are mail-order suppliers of saw chain, tools, and accessories.

Zip Penn, Inc.
2008 E. 33rd St., P.O. Box 179
Erie, PA 16512

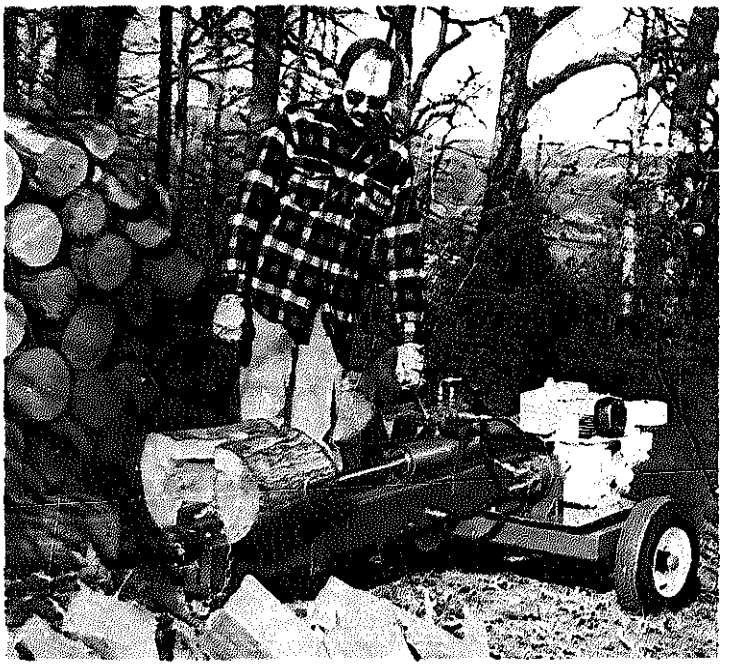
WHEN AN AXE IS NOT ENOUGH

by Steve Smyser

Log splitters have been on the market for years, but until recently they've been a rather specialized tool used exclusively by professionals. When the energy crunch pushed oil prices up and wood stove sales spiraled, many homeowners started looking seriously at commercial splitters. Certainly nobody is about to predict the demise of the axe, sledge, and wedge. Many folks still cut their entire year's supply of fuel wood by hand, enjoy it immensely, and have no interest whatsoever in mechanical alternatives. The commercial splitter has yet to be invented that can simulate the pure joy of chopping wood on a crisp October afternoon and stacking it away in warm anticipation of winter's worst.

On the other hand, sales figures and a proliferation of new manufacturers in the field bear witness to the steadily increasing number of people who heat with wood and prefer to cut it themselves, but who lack the time or inclination to do it all by hand. For this group, which often includes neighbors making a joint purchase, or individuals interested in starting a part-time cordwood business, the mechanical splitters have been a real boon. It takes most of us the better part of a day to cut, split, and stack a cord of poplar or apple with a chain saw and wedge. With a power splitter, the job takes about half that time.

Wood-splitting devices being sold today are principally of either the hydraulic wedge type or the screw type. The latter variety comes as either a self-powered unit or a bolt-on type that attaches to a tractor PTO shaft or to the rear wheels of a car or truck.



The larger hydraulic units like this go through a cord of wood an hour with ease. Their heavy-duty rams (10 tons of splitting force) make them the choice for frequent splitting of exceptionally dense, stringy wood.

The hydraulic wedge-type splitter used by most professionals is basically a hydraulic cylinder forcing a log through a splitting wedge. The better models generate about ten tons of splitting force from heavy-duty cylinders and gas engines ranging from four to eight horsepower. Most manufacturers offer two sizes of bed (the I-beam or square tubing on which the log rests), one for logs up to 19 inches and another for logs to 26 inches. Cycle times (the time required for the ram to travel to the wedge and return) for various models range from 12 to 30 seconds, a difference that would be important if you are in the cordwood business. Most hydraulic splitters can get through a cord of wood in an hour with no trouble.

As logs are split, they will shift around a bit to follow the grain of the wood. For this reason, the forward speed of the hydraulic ram should be slow enough to give the operator time to avoid a mishap. Some makers offer two-stage hydraulic pumps with this in mind: the two-stage pump provides fast speed with low force for normal operation, then shifts automatically to low speed/high force when additional pressure is needed to split tough or gnarled logs.

The cost of these hydraulic units ranges from $600 for most of the popular four and five horsepower models up to $1,200 and more for some of the more sophisticated professional versions.

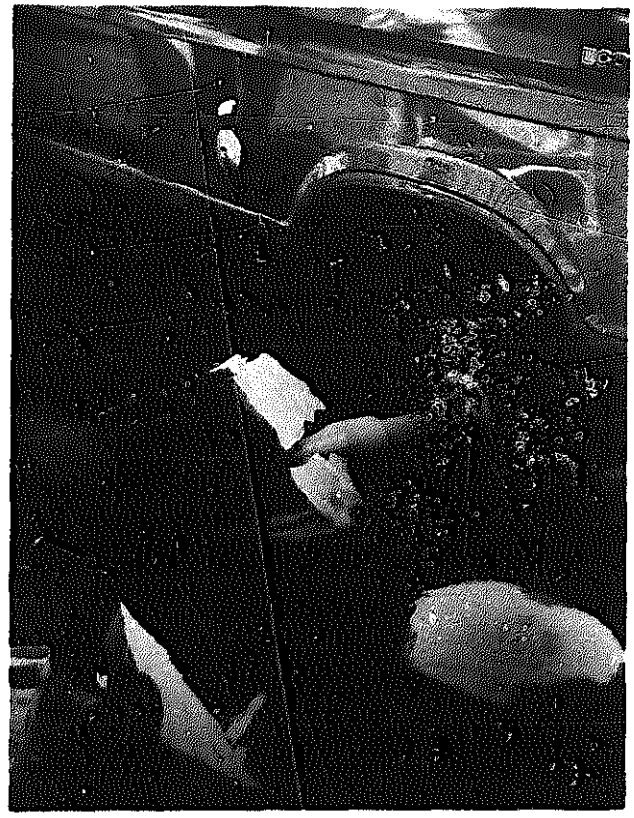
A real breakthrough in the design of commercial wood splitters occurred three years ago with the debut of the auger screw-type splitter. Designed largely in response to the burgeoning farm and home market, the screw-type splitters are made to penetrate logs up to 28 inches in diameter and literally screw them apart. In addition to portable, self-powered units, the screw-type splitters come in models that bolt onto auto and truck wheels and tractor PTO shafts. The bolt-on models cost less than the self-powered splitters ($200 as contrasted wih $400 and up), but require an adapter if you switch to a vehicle with different size lug holes on the wheels.

While quite rugged and satisfactory for almost all home-scale splitting requirements, these eight- and nine-horsepower units must take a back seat to the more powerful hydraulic models when it comes to continual cutting of dense, stringy woods like locust, elm, and willow.

To use the bolt-on type of screw splitter, you press the log into the turning screw, making sure each log is offset so that its lower end butts against the ground and prevents the log from spinning. The threads simply pull the log onto the widening screw and split it open, usually in about 10 to



The screw-type log splitter: as a separate unit (left), and as a truck-mounted model (below). Each has advantages and disadvantages.



12 seconds. A safety switch is attached to the engine, allowing the splitter to be turned off from the work area.

Along with the advantage of operating independently of problem-prone small engines and hydraulic systems, the bolt-on screw permits the operator to split large, heavy logs without lifting them off the ground. The self-powered screw units, on the other hand, do not require jacking up your car or truck every time you need to do some splitting.

How do you determine which type is right for you? It depends largely on what kind of wood you work with most often. If you're splitting nonstringy wood like ash, beech, maple, birch, apple, or any wood that splits cleanly with a wedge or an axe, you should probably lean toward the screw-type splitters, which are generally faster and less expensive than the hydraulic units. If you're splitting heavy, dense, and stringy wood like black gum, elm, locust, yellow birch, hackberry, oak or any wood that does not split cleanly with a wedge—any wood that requires an axe to cleave off stubborn strings or strands that prevent a clean split—then you need a hydraulic unit. If you try to split dense, stringy wood on a screw-type splitter, you will spend as much time trying to pull the wood on the screw as you spend on splitting.

What size machine should you buy? Again, it depends on your objective. If you're splitting logs 12 inches wide by 16 inches long, there's no reason to buy a ten-ton hydraulic ram with a 24-inch bed.

Conversely, don't count on a small screw-type unit to routinely split oak logs three feet long by 30 inches across.

In general, if you're splitting logs under 19 inches in length or 20 inches in width, you can buy what most manufacturers call their homeowner models and be fully confident that the machine will do your work. You can, on occasion, split larger logs if you follow the instructions that come with the machine; but if you're going to split larger logs on a regular basis, you should look at professional models. Buying a homeowner model to split logs 30 inches long by 30 inches wide is like buying a half-ton pickup to deliver ten tons of coal every day—you're going to destroy the machine by forcing it to do more than it was designed for.



Mounted on a three-point hitch, this hydraulic attachment for the Power King Tractor splits logs up to 26 inches in a 15-second cycle.
Engineering Products Co.



An increasing interest in woodlot harvesting has encouraged manufacturers to develop tractor-run equipment. The Wheel Horse D-Series demonstrates both log splitter and saw.

How much should you pay for a splitter? Don't be fooled by price—the least expensive machine you can buy is the unit that fits the requirements of your work. Buy a machine that's smaller than you need, and you're going to spend your savings in repairs. Buying a unit that's larger than you need is wasteful in that you're spending more than you have to in order to get the job done.

When shopping, beware the dealer who stocks one or two models and tells you that his machines will do anything. How does he know? Has he ever split wood? If you're going to buy a splitter, find a dealer who has paid his dues, someone who has split and burned a lot of wood, and who knows the difference between a sledgehammer and a splitting maul.

There is no one machine that will do everything. The inexperienced dealer or manufacturer may try to persuade you that his equipment will handle whatever you're splitting. A good dealer will demonstrate his product thoroughly, and perhaps even let you use it for a week. Who knows, you may discover you prefer swinging that axe after all!

SOURCES OF COMMERCIAL WOOD SPLITTERS

Hydraulic Wedge Types

Mighty Mac
This unit comes in 5 and 7 h.p. models.

Amerind-MacKissic, Inc.
Box 111
Parkerford, PA 19547

Hydra-Splitter
Available in a 4 h.p. unit, the Model 26 TM hooks to tractor hydraulics.

Didier Mfg. Co.
Box 163, 8630 Industrial Dr.
Franksville, WI 53126

Lickity Splitter

This model is available from:
Piqua Engineering, Inc.
Box 605
Piqua, OH 45856

Futura Enterprises
West Bend, WI 53095

Huss Sales & Service
Toledo, OH 43601

Lindig Splitters
These splitters come in a 3 h.p. compact size, and 5 h.p. two-stage model; both have a tractor-mount option.

Lindig Splitters
1875 W. County Rd.
St. Paul, MN 55112

Power King Tractors
This firm markets tractor-mounted hydraulic splitters.

Engineering Products Co.
1525 E. Ellis St.
Waukesha, WI 53186

Farnum Log Splitter
Farnum Companies, Inc.
Box 12068
Omaha, NE 68112

Futura
Futura Master Corp.
5069 Highway 45 South
West Bend, WI 53095

Woodsman
G.S.I. Corp.
Box 39
Jackson, WI 53037

Household Wood-Splitter
Box 143
Jeffersonville, VT 05464

Screw Types

Stickler
This splitter can be wheel-mounted or run from a tractor PTO.

Taos Equipment Manufacturers
Box 1565
Taos, NM 87571

Bark Buster
This is a self-powered screw-type splitter.

FW and Associates, Inc.
1855 Airport Rd.
Mansfield, OH 44903

Quick Split

This self-powered splitter comes in 5 and 8 h.p. models.

Trans America Power Equipment, Inc.
8308 Washington St.
Chagrin Falls, OH 44022

Derby Splitter

This self-powered portable splitter is available as an 8 h.p. model or a tractor PTO-driven unit.

Derby Splitter
Box 21
Rumson, NJ 07760

The Unicorn

This is a wheel-mounted or bolt-on splitter.

Thackery Co.
Columbus, OH 43216

Nortech Splitter

This company offers a self-powered 8 h.p. splitter.

Nortech Corp.
Midland Park, NJ 07432

Knotty Wood Splitter

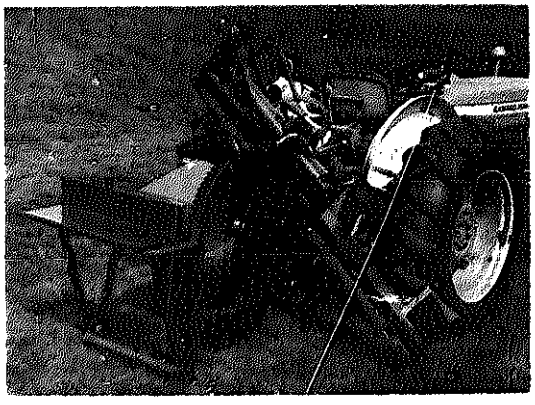
This unit is driven by a tractor PTO.

Knotty Wood Splitter Co.
Route 66
Hebron, CT 06248

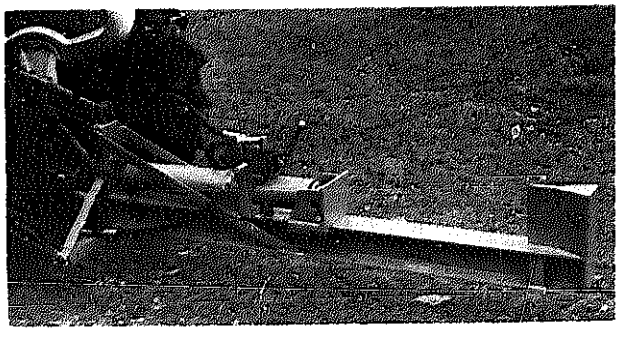
Other Splitters

Pokrandt Splitter

This is a tractor-mounted combination cordwood saw and wood splitter.



Pokrandt's tractor-mounted cordwood saw and wood splitter. Units may be purchased and mounted separately, like the hydraulic wedge splitter.
Richard Pokrandt Manufacturing



MATCHING THE SPLITTER WITH THE WOOD

Clean and Easy-to-Split Woods
Hemlock, ash, beech, poplar, hickory, hornbeam, maple, cherry, apple, aspen, white birch, spruce, basswood, oak.

For logs up to 19 inches long by 20 inches wide, use a homeowner screw type splitter.

On logs 19 to 36 inches long by 20 to 30 inches wide, use professional hydraulic or professional screw-type unit with a minimum of 8 h.p.

Stringy, Hard-to-Split Woods
Elm, black gum, hackberry, eucalyptus, pinyon, locust, willow, yellow birch.

On logs up to 19 inches long by 18 inches wide, use a homeowner hydraulic splitter. (Screw-type units are often inadequate for these woods).

On logs 19 to 36 inches long by 18 to 30 inches wide, use a professional hydraulic splitter. (Screw-type units not recommended for these woods).

Richard Pokrandt Manufacturing
RD. 3, Box 182
Tamaqua, PA 18252

Jiffy Woodsplitter

This is an upright, guided-wedge-type splitter.

C & D Distributors, Inc.
Dept. O, Box 766
Old Saybrook, CT 06475

Thrust Log Splitter

This is a nonhydraulic horizontal wedge.

Thrust Mfg., Inc.
6901 S. Yosemite
Englewood, CO 80110

Knotty Wood

They offer a tractor-driven cordwood saw.

Knotty Wood Splitter Co.
Route 66
Hebron, CT 06248

Woodland Splitters
P.O. Box 976
Oak Brook, IL 60521

Hand-Operated Hydraulic Splitter

Woodland Splitters
P.O. Box 976
Oak Brook, IL 60521

Tractor-Mounted Log Splitter

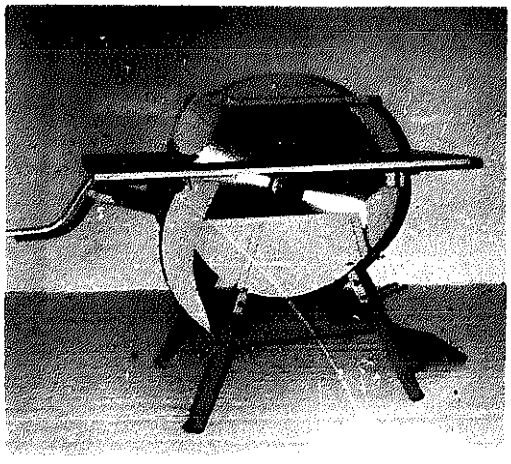
SI Mac Design
9 Vista Verde
Portola Valley, CA 94025

SAWMILL EQUIPMENT

Gaubert Saws

Gaubert makes a series of electric circular saws with 500 or 600 millimeter blades for both sawing logs and rough-cutting lumber. Tractor PTO and three-point-hitch adaptations are also available.

A. Gaubert 16700
16700 Ruffec
Bordeaux, France



Gaubert Circular Saw Gaubert

Speedy Cord Saw

This saw will cut hardwood slabs or logs to 8 inches in diameter at the rate of 120 cubic feet (about a pickup load full) in 30 minutes time. Three models are available; one trailer, one three-point-hitch mount, and one on skids.

Speedy Cord Saw
Winona Attrition Mill Co.
1009 W. 5th St.
Winona, MN 55987

Mini-Mite

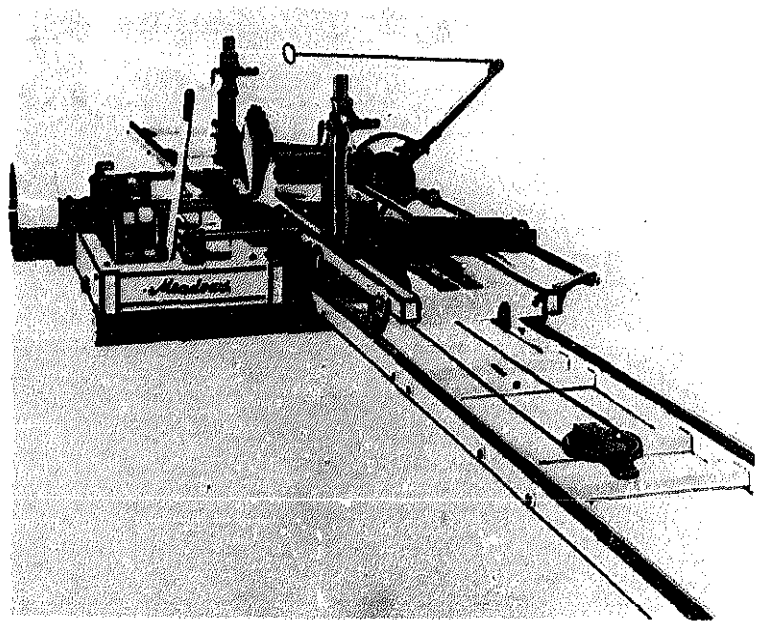
The Mini-Mite can handle logs up to 18 feet in length. Equipped with hydrostatic carriage drive, the unit can produce true dimension lumber with a maximum cut of 4½ inches by 12½ inches. The saw is designed to be towed with a pickup and can be set up on the site in 45 minutes.

Mini-Mite Transportable Sawmill
International Enterprises of America, Inc.
3931 N.E. Columbia Blvd., P.O. Box 20427
Portland, OR 97220

Meadows Portable Mill

Easily moved and set up, the Meadows No. 1 mill features a 15 foot carriage on four sets of roller bearing travelers, 6 inch wheels, and a 48 inch blade.

Meadows Portable Sawmill
North Wilkesboro, NC 28659



Meadows No. 1 Standard Saw Mill
Meadows Mills Co.

Pokrandt

Pokrandt manufactures a tractor-mounted combination cordwood saw and wood splitter. The saw is driven off a tractor PTO; the wood-splitter is powered by the tractor's hydraulic system. Units may be purchased separately.

Richard Pokrandt Mfg.
RD 3, Box 182
Tamaqua, PA 18252

Belsaw

Belsaw offers a variety of power sawmill equipment, including two sizes of sawmills, a self-feed rip saw, and a chain saw grinder. The smaller mill handles logs up to 18 inches in diameter, 14 feet in length, while the large mill will take a 36 inch diameter, 24 foot log.

Belsaw Power Tools
4103 Field Bldg.
Kansas City, MO 64111

Glen-Bel's Country Store
Rt. 5
Crossville, TN 38555

Laredo

The Saw and Emery Laredo Model SEL-005 requires 3 to 5 h.p., and is available in two models: with stationary engine or three-point tractor PTO. The saw (14 inches in diameter) and the emery (12 inches diameter) will reach a maximum 2,200 rpm.

Laredo, S.A. Industria e Comercio
Rua 1 de Agosto, 11-67
17.100 Bauru (SP), Brazil

WINCHES

Fulton 900

Fulton's 900 Series winches are available with rated load capacities of 1,000, 1,500, and 2,500 pounds. Special features include a Load-Lok automatic brake system and large drum diameters for use with steel cable.

Fulton Mfg. Co.
1912 S. Eighty-second St.
Milwaukee, WI 53219

Lug All

Lug All makes cable ratchet lever winch-hoists in ½ to 3 ton capacities. Designed to lift, pull, lower, bend, or stretch in any position and at any angle, Lug All winch-hoists are available with all types of hooks and with cable lengths up to 50 feet.

Lug All
538 Lancaster Ave.
Haverford, PA 19041

Forestry Suppliers, Inc.
Box 8397
Jackson, MS 39204

Superwinch

These 12-volt electric winches come in 12 different models. The winches bolt on to a vehicle's bumper and draw power from the battery.

Superwinch, Inc.
Connecticut Route 2
Putnam, CT 06260

Trewhella Monkey Winch

Designed for pulling up trees and hedges, and for land clearing, the Monkey Winch is strong and light and has two speeds and a reverse gear. A lightweight model, the Spacemaker, is recommended for pulling, lifting, and clearing small trees. The Monkey Wire Strainer for mending broken fences or stretching new wire is also available.

Trewhella Monkey Winch
Trewhella Bros., Ltd.
Rolfe Street, Smethwick
Warley, West Midlands, B66 2BA, U.K.

Sasgen

Sasgen makes all-purpose winches in 2, 5, and 15 ton capacities. An automatic safety brake handle holds the load in any position.

Sasgen Derrick Co.
3101 W. Grand Ave.
Chicago, IL 60622

Tirfor

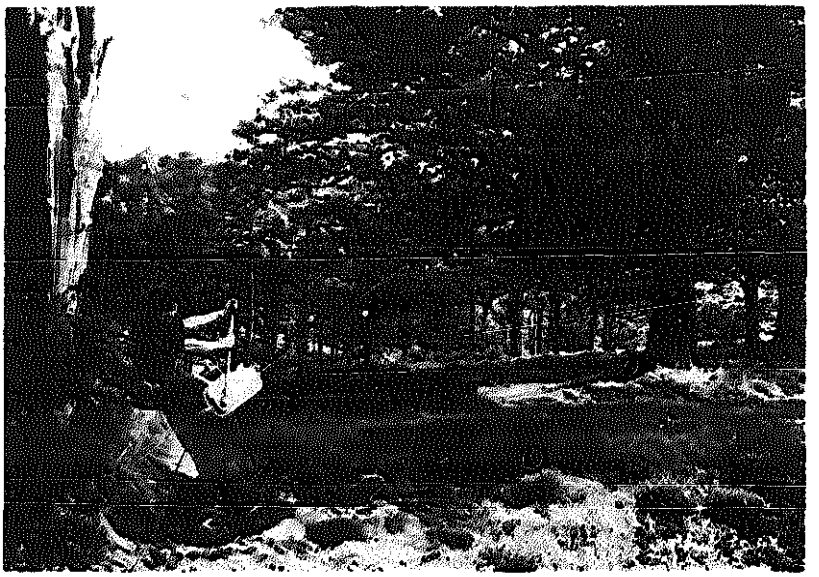
The Tirfor is a fully portable pulling-lifting or lowering machine that can be used for many purposes, including tree felling. It can increase the human effort by up to 85 times.

Tirfor Lifting & Pulling Machines
Tirfor, Ltd.
Halfway, Sheffield S19 5GZ, U.K.

Fulton General Purpose Winches

Fulton winches come in load capacities ranging from 900 to 1,500 pounds; all feature a one-piece reinforced frame, two-way ratchets, and gears of high carbon steel. Also listed in these catalogs are free-spooling winches, come-alongs, a variety of hoists, and screw and mine-type jacks.

Cumberland General Store
Box 479, Rt. 3
Crossville, TN 38555



Tirfor Lifting Machine

Glen-Bel's Country Store
Rt. 5
Crossville, TN 38555

Belknap, Inc.
P.O. Box 28
Louisville, KY 40201

Airborne

Airborne, a government surplus store, offers a wide variety of hand and electric winches. Maximum capacities of the hand winches range from 1,200 to 2,000 pounds; the larger electric winches, designed for more rugged use, have 4,000 to 8,000 pound pull ratings.

Also available are hand-operated rope pulls, which combine hoist, winch, and puller for smaller jobs around the home or farm.

Airborne Sales Co.
8501 Steller Dr., P.O. Box 2727
Culver City, CA 90230

More-Power Puller

The More-Power Puller is a portable, two-ton block and tackle unit with 5/16 inch wire cable in 20, 30, or 40 foot lengths.

Wyeth-Scott Co.
85 Dayton Rd., Rt. 16 East
Newark, OH 43055

Forestry Suppliers
P.O. Box 8397
Jackson, MS 39204

VITA Overhead Hoist

VITA is an international service agency that functions as a clearinghouse for information on village-scale technology and low-energy agricultural methods. Among the voluminous plans they have developed for international distribution (primarily to developing countries) is this easily constructed tripod-type hoist that can be either electrically powered or hand operated. VITA also has a plan for a jack-type post puller made of angle iron and a clevis and chain.

Volunteers in Technical Assistance
3706 Rhode Island Ave.
Mt. Rainier, MD 20822

Levalift

Levalift 117 Pull Hoist, a general-purpose pulling machine, can be used for large jobs, such as extracting trees. It is available in 3/4, 1 1/2, 3, and 4 1/2 ton sizes.

Herbert Morris, Ltd.
P.O. Box 7
Loughborough LE11 1RL, U.K.

Wire Strainers

Wire Strainers/Stretchers, useful for mending broken fences or stretching new wire around posts, vary in their pulling and holding capabilities. Certain models are for smaller tasks and utilize conventional chain; others require heavy-duty chain and can be used on many types of wire.

G.V. Donald Africa (Pty), Ltd.
P.O. Box 1439
Port Elizabeth 600 S. Africa

Berry-Hill, Ltd.
75 Burwell R.d.
St. Thomas, Ontario, Canada

Trewhella Bros., Ltd.
Rolfe St., Smethwick
Warley, West Midlands B66 2BA, U.K.

Drival, Ltd.
Churchbridge, Wks
Cannock, Staffs WS1 3JP, U.K.

Hans Nicolaisen
Box 18
Plainfield, NH 03781

Banana Conveyor

A winch-powered conveyor has been developed by the Overseas Department of NIAE to meet the needs of banana producers for a simple, mechanical carrying system to transport bananas from the field to the boxing plant. The conveyor, the department feels, may possibly be used in other field transport situations.

Powered either by hand or electric winch, it includes branch lines, ravine crossings, transfer rails, and switch points. A booklet describing the whole system and its components is available from the Overseas Department of the NIAE.

Tropical Agricultural Engineering Information
Overseas Department
National Institute of Agricultural Engineering
Silsoe, Bedfordshire, U.K.

Heavy-Duty Shrub Puller

Anchoring this tool to the ground by foot, the operator grasps the shrub, cotton stalk, thistle, sorghum or maize roots, or young tree in the jaws of this tool, and removes the stem by pulling back on the tall handle. No bending is involved. The maximum jaw opening is two inches.

Project Equipment, Ltd.
Rednal Ind. Estate
Oswestry, Salop, UK

Hans Nicolaisen
Box 18
Plainfield, NH 03781

POWER SCYTHES

Echo SRM

This is a shoulder-type brush cutter with a two-cycle engine integrated into the operating rod. It features a safety guard, muffler, and vibration-damping cushions, with a total weight of 6.8 kilograms.

Echo SRM, Echo Chain Saw Div.
Kiorita Corp. of America
350 Wainwright
Northbrook, IL 60062

CeCoCo Power Scythe

Shoulder- or knapsack-mounted scythe features a 1.2 h.p., two-cycle engine that is independently suspended for minimum vibration and heat. Circular blade automatically stops rotating when it comes in contact with a stone or other obstacle. Weight: 11 kilograms.

CeCoCo Power Scythe
P.O. Box 8, Ibaraki City
Osaka Pref 567 Japan

Stihl Brush Cutters

Stihl produces a complete line of power brush cutters ranging from the very light FS150 to the professional FS202. Larger models are available with either two-cycle or electric engines. The variety of available cutting tools includes brush knives, grass trimmers, chipper tooth blades, and scratcher tooth blades.

Stihl Inc.
Box 5514
Virginia Beach, VA 23455

Andreas Stihl Maschinenfabrik
Postfach 64
705 Waiblingen, West Germany

Kyoritsu Power Scythe
Kyoritsu Noki Co., Ltd.
Seiwa Lbd., 1-6-8
Nishishinjuku, Shinjuku-ku
Tokyo 160, Japan

Hoffco Power Scythe

Comet Industries
25 Washington Ave.
Richmond, IN 47374

Rowco Brushking

Rowco Mfg. Co., Inc.
48 Emerald
Keene, NH 03431

Alpina Brush Cutters

There are three models, ranging from 1.5 to 2.5 h.p., and they can be used by the homeowner or the professional.

Alpina S.P.A.
31015 Conegliano
S. Vendemiano (TV), Italy

Alpina North America
Mr. H.J. Hutchinson
Box 313
Trail, British Columbia V1R 4L6, Canada

Husqvarna Clearing Saw

Accessories for this power saw include a harness for the operator, and two sizes of blade guard. The engine is a two-stroke, single-cylinder, air-cooled model, and weight without harness or transport blade guard is 10.6 kilograms.

Husqvarna Vapenfabriks AB
Husqvarna, Sweden

Husqvarna
151 New World Way
South Plainfield, NJ 07080

ORCHARD HARVESTING EQUIPMENT

Friend Orchard Equipment

Their canvas bags and buckets are durable harvesting bags for all kinds of fruit, including special designs for peaches and easily bruised apples. Picking straps and picking harness are also available separately.

Orchardkraft wood ladders are designed especially for fruit harvesting; they have a wide flare bottom and are well balanced. Available in open top style, pointed top style and three-point step ladders. Also have extra-strong aluminum ladders. Other harvesting equipment is also available.

Friend Mfg. Corp.
Gasport, NY 14067

Maktefot Picker

This is a lightweight pole-and-sleeve-type picker designed to cut stems at exactly the proper length, and thus minimize spoilage. The aluminum rod telescopes to 12 millimeters, with the woven linen chute having internal baffles to cushion the fruit fall.

Maktefot, Ltd.
12 Hadekalim St.
Hod Hasharon, Israel

Pflucki Fruit Gatherer

The Pflucki Fruit Gatherer, a small pole-mounted unit appropriate for cherries and plums, snags the fruit stem in a set of metal tines and drops the fruit into a small plastic box.

Metallwarenfabrik Naegeli AG
P.O. Box CH-8594
Guettingen, Switzerland

Pole Picker

This pole-mounted avocado picker, equipped with a nylon bag to catch fruit, can be mounted on any size pole. A collapsible aluminum pole that extends for several meters for tall trees, as

well as grape shears and pruners, are also available.

Tachsir Ltd. Metal Works
25 Hamlacha St.
Holojn Industrial Center, Israel

Pinza Cogliolive (Olive Pluckers)

These pliers have a patented rolling device which allows them to slide along branches to harvest olives without damage to the branches or fruit.

Felli Deidone
Villafranca Verone
Via A. Messedaglia, 20, Italy

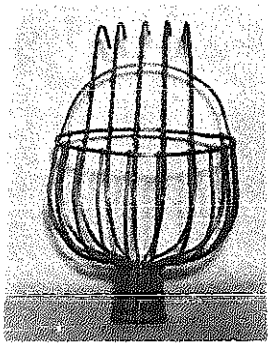
Cumberland Fruit Picker

Made from galvanized wire, this fruit picker attaches to any round-ended pole.

NORTH AMERICAN SOURCES OF WOODLOT HAND TOOLS

	PEAVIES	AXES	MAULS	KNIVES, BILLHOOKS	ASS'T. TOOLS FOR WOODLOT	HAND AUGERS, POST HOLE DIGGERS
AMES		X	X	X	X	X
ANCHOR		X		X		
BULLDOG		X				
COUNTRYSIDE			X			X
CUMBERLAND	X	X	X	X	X	X
GLEN-BEL		X	X			X
A.M. LEONARD	X	X	X	X	X	X
STANLEY HYDRAULIC TOOLS				X	X	
TRUE TEMPER		X	X			X
UNION FORK			X			X
MOTHER'S GENERAL STORE		X		X	X	
NASCO		X	X	X		
FORESTRY SUPPLIERS	X	X	X	X	X	X
SEYMOUR SMITH & SON, INC.					X	
SOTZ CORP.			X			
OLEY TOOLING, INC.				X		
TRADEWINDS, INC.						X
SEYMOUR MFG. CO.						X
BELKNAP, INC.	X	X		X	X	X
CENTRAL TRACTOR					X	

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555



Cumberland Fruit Picker
Cumberland General Store

Tree Stand

For hunters, photographers, bird and animal watchers, tree trimmers, and fruit pickers, this stand can be locked in a tree with its poly rope and eccentric locking handle without damage to the tree. The tree stand will remain securely fastened in the tree, even with movement of the stand user.

Wamco
1009 W. Fifth St.
Winona, MN 55987

INTERNATIONAL SOURCES OF WOODLOT HAND TOOLS

	PEAVIES	AXES	MAULS	KNIVES, BILLHOOKS	ASS'T. TOOLS FOR WOODLOT
CEAF S.N.C.F. LLISILETTI		X		X	
ENGLISH TOOLS, LTD.		X		X	X
FERFOR		X	X		
FISKARS, AB	X	X		X	
HINDUSTAN ENGINEERING CO.				X	
KUMAON AGRI-HORTICULTURE STORES	X			X	
KUMAON NURSERY		X		X	
KUMAR INDUSTRIES		X			X
GEO. PIKE, LTD.		X			
SOCIETE DES FORGES TROPICALES		X			
FRANZ SONNLEITHNER K.G.				X	
SPEAR & JACKSON TOOLS, LTD.		X		X	X
STANLEY GARDEN TOOLS, LTD.				X	
SYNDICATE DE L'OUTILLAGE		X		X	X
W. TYZACK SONS & TURNER, LTD.				X	
UBUNGO FARM IMPLEMENTS		X		X	X
UNITED REPUBLIC OF TANZANIA				X	
WOLF AND BANGERT WERKEUG FABRIK				X	

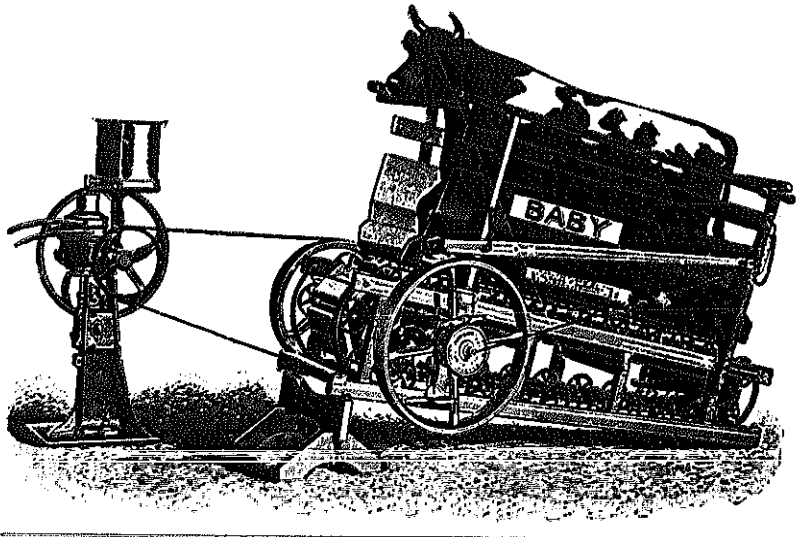
-11- Livestock Equipment

Depending on the type of livestock and the actual number of animals or birds a farmer raises, equipment may be a large expenditure or a relatively small one. A handy farmer can build his own pens, coops, fences, feeders, and small buildings.

The following sources carry most of the equipment in which you might be interested for raising poultry, rabbits, pigs, cows, or horses. Other local raisers, the cooperative extension agent, and magazines devoted to a specific animal or breed can also be helpful in locating information on equipment.

GENERAL SOURCES OF LIVESTOCK EQUIPMENT

Brower Mfg. Co.
640 S. Fifth St.
Quincy, IL 62301



Her work is never done! In an old advertisement, we see the family cow separating her own cream with treadle power—illustrating the true meaning of self-sufficiency.
The Farm Implement News, 1894

Nasco Agricultural Sciences
901 Janesville Ave.
Fort Atkinson, WI 53538

A variety of feeders, waterers, hog equipment, nursing equipment, and poultry equipment is offered.

The Pearson Bros. Co.
P.O. Box 192
Galva, IL 61434

They offer a wide variety of specific equipment for most farm animals, a large assortment of veterinary supplies, feeders, waterers, transporting equipment, and related agricultural supplies.

Feeders, waterers, stalls, and farrowing crates are available.

Quinn Machinery Division of Zeidlers, Inc.
Box 130
Boone, IA 50036

This company manufactures Daisy gravity and pressure waterers.

Shenandoah Mfg. Co.
Box 839
Harrisonburg, VA 22801

A variety of feeders and waterers, brooders, and metal nests can be found.

Southeast Mfg. Co., Inc.
Route 2 Box 275
Joplin, MO 64801

They carry stock racks for transporting small animals in pickup trucks and large portable hay feeders.

Tomsicek Mfg. Co.
1419 Adams Blvd.
Ithaca, NE 68033

They manufacture portable hay feeders.

Wadler Mfg. Co., Inc.
Route 2 Box 76
Galena, KS 66739

They carry oilers, livestock scales, hay feeders, assorted chutes, and crates.

WLC Co., Inc.
Sedlia, IN 56067

They have a wide variety of feeders, farrowing crates, stock tanks, and gates.

INTERNATIONAL SOURCES OF GENERAL LIVESTOCK EQUIPMENT

Ets Louis Tellier
Athies-Sous-Laon
02000 Laon, France

Large transport equipment for livestock and feeders are available.

SKA s.a.s.
36066 Sandrigo (VI)
Italy

This company offers equipment for small- to large-scale livestock raising, including poultry, rabbits, cattle, and swine.

NORTH AMERICAN SOURCES OF RABBIT SUPPLIES

Bass Equipment Co.
Box 352
Monett, MO 65708

They handle a full line of rabbit-raising equipment.

Maple Grove Rabbit Farm
Chadsey Rd.
Pownal, ME 04069

A wide range of rabbit-raising equipment, rabbits, and books are offered.

Mother's General Store
Box 506
Flat Rock, NC 28730

They stock metal hutches and drinking tubes.

Nasco Agricultural Sciences
901 Janesville Ave.
Fort Atkinson, WI 53538

Feeders are available.

WLC Co., Inc.
Sedalia, IN 46067

Nest boxes, feeders, waterers, and hutches are available.

INTERNATIONAL SOURCES OF RABBIT SUPPLIES

Self-Sufficiency and Small-Holding Supplies
The Old Palace, Priory Road
Wells, Somerset BA 5 1SY, U.K.

Waterers; cage-size hay racks.

NORTH AMERICAN SOURCES OF SUPPLIES FOR COWS, CALVES, AND DAIRYING

American Village Institute
440 Meyers St.
Kettle Falls, WA 99141

They offer a butter churn, butter molds, and a butter paddle.

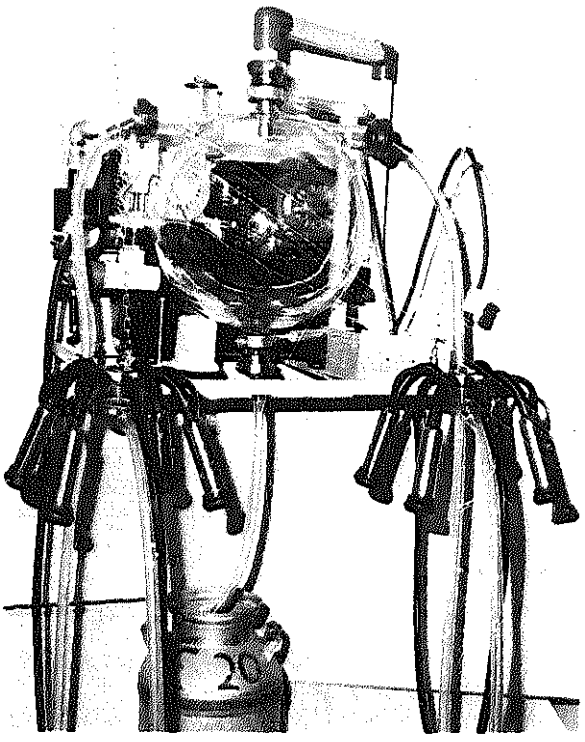
Belknap, Inc.
Box 28
Louisville, KY 40201

This company manufactures halters, leaders, feeders, weaners, kickers, dehorners, and bells.

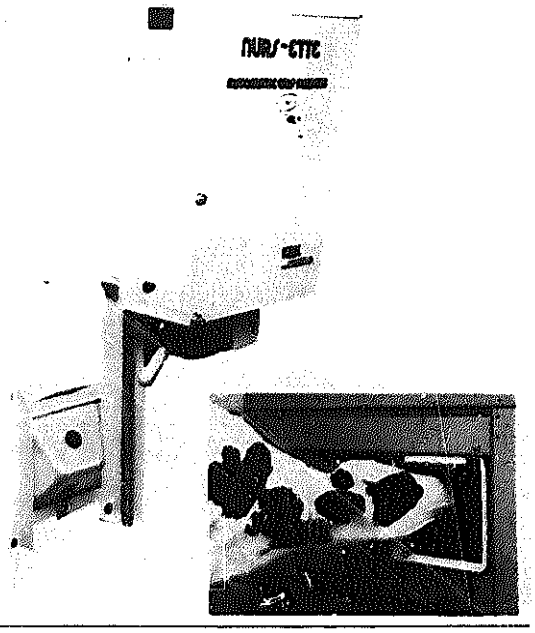
Chore-Boy Division
Gloay and Co. Inc.
Cambridge City, IN 47327

They carry milking systems.

Countryside Catalog
Route 1, Box 239
Waterloo, WI 53594



The Chore-Boy Milking System: a two-unit pipeline system that can be installed and in use in an hour.
Gloay and Co.



K & K Nurs-Ette Automatic Calf Feeder
K & K Mfg.

Milking pails are available.

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

They have nursery items including nipples, calf weaner, cow kicker, bull rings, horn weights, dehorner, bells, halters, and health care accessories.

Glen-Bel Country Store
Rt. 5
Crossville, TN 38555

They offer cattle leaders, dairy halters, bull rings, bells, calf weaners, cow kickers, and grooming aids.

K & K Mfg., Inc.
Rogers, MN 55374

They have Nursette feeders for calves, bottle feeders, and dry automatic feeders.

K-W Mfg. Co., Inc.
800 Marion Rd.
Sioux Falls, SD 57106

They have pole syringes and calfers.

Marting Mfg.
Washington Court House, OH 43160

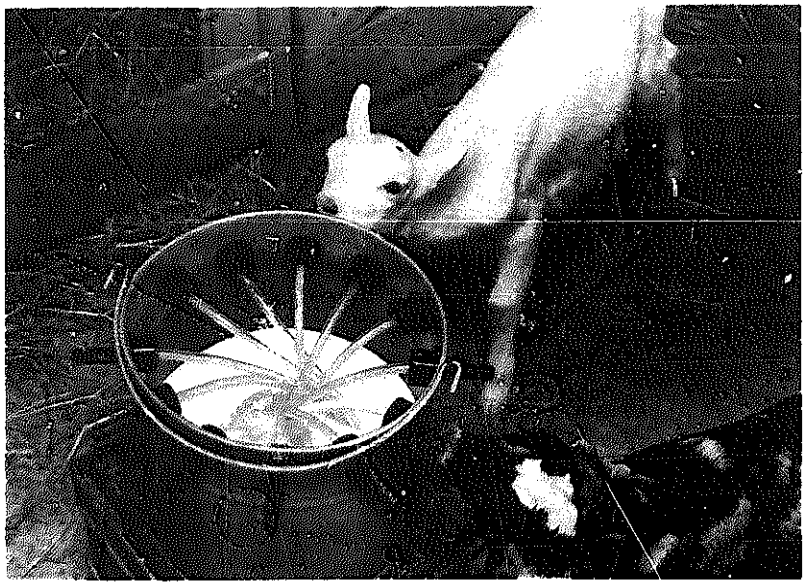
Feeders, waterers, scales, chutes, shelters, and oilers are available.

Montgomery Ward (catalog)
1000 S. Monroe St.
Baltimore, MD 21232

There are stock tanks, feeders, waterers, tagging guns, home pasteurizers, and milk filters.

Mother's General Store
Box 506
Flat Rock, NC 28731

Halters and bells are available.



Parts are available for making your own feeder.

Nasco Agricultural Sciences
901 Janesville Ave.
Fort Atkinson, WI 53538

There is a wide variety of halters and leads, grooming accessories, hoof and horn equipment, blankets, home pasteurizers, and a wide assortment of dairying equipment including testing supplies.

Sears, Roebuck & Co.
Farm and Ranch Catalog

They have feeders, milk pasteurizers and butter churns.

Schoessow, Inc.
Rt. 2
Pulaski, WI 54162

They have large wagon feeders and gates.

NORTH AMERICAN SOURCES OF GOAT SUPPLIES

Countryside Catalog
Rt. 1, Box 239
Waterloo, WI 53594

They have harnesses and dairying supplies.

Hoegger Supply Co.
Box 490099
College Park, GA 30349



This peculiar-looking device is an aid to keeping those pesky, sometimes dangerous, flies and other insects off your cows. It is a canvas roll which is filled with any absorbent material like cotton rags. The roll is then saturated with rotenone and lubricating oil and suspended between two poles slightly lower than the back height of an average cow. The animals, after an introduction by walking them under the roll once or twice, will return to it on their own, says Gayle Treadwell of Beeville, Texas; it keeps insects under control.

New Delphos Mfg. Co.
Delphos, OH 45833

They have a variety of feeders, waterers, metal nests, and vent accessories.

Ronson Farms
P.O. Box 12565
Columbus, OH 43212

They offer feeders, incubators, brooders, cages, poultry pickers, chicks, pigeons, pheasants, waterfowl, quail, doves, books, and aviary accessories.

Sears, Roebuck & Co.
Farm and Ranch Catalog

They list feeders, waterers, steel poultry nests, cartons, chickens, ducklings, goslings, and mallards.

Stromberg's Pets Unlimited
50 Lakes Route
Pine River, MN 56474

They carry feeders, waterers, incubators, chicken pluckers, chicks, bantams, ducklings, goslings, and books.

Productions Master S.A.
Apartado Postal 74-057
Calzada de Tlalpan 1606
Mexico 13, D.F.

Feeders, waterers, and brooders are available.

INTERNATIONAL SOURCES OF POULTRY SUPPLIES

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

They have egg washers and sorters.

Dalton Supplies, Ltd.
Nettlebed, Henley on Thames
Oxon, U.K.

They carry marking equipment.

PAL, Ets. P. Lecieux & Cie
rue du Riez
59112 Annoeullin, France

Feeders and brooders can be ordered.

Self-Sufficiency and Small-Holding Supplies
The Old Palace, Priory Road
Wells, Somerset BA 5 1SY, U.K.

Feeders, poultry houses, and identification equipment can be found here.

NORTH AMERICAN SOURCES OF SHEEP SUPPLIES

Belknap, Inc.
P.O. Box 28
Louisville, KY 40201

They carry shears.

Columbia Cutlery Co.
P.O. Box 123
Reading, PA 19603

They have a variety of sheep shears.

Countryside Catalog
Rt. L, Box 239
Waterloo, WI 53594

They have shears and wool cards.

K & K Mfg., Inc.
Rogers, MN 55374

They carry Nursette lamb feeders, nipples, and tube assembly parts.

Nasco Agricultural Sciences
901 Janesville Ave.
Fort Atkinson, WI 53538

They offer marking equipment, cards, halters, blankets, nursing supplies, castrators, lambing instruments, and a variety of shears.

INTERNATIONAL SOURCES OF SHEEP SUPPLIES

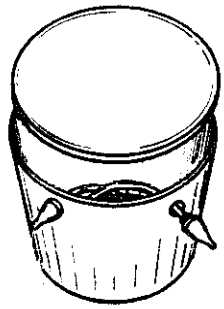
Dalton Supplies, Ltd.
Nettlebed, Henley on Thames
Oxon, U.K.

They have lamb-bar feeders, lambing instruments, ram harnesses, ewe-bearing retainers, and castration rings.

Kumaon Nursery
Ramnagar
Nainital, U.P. India

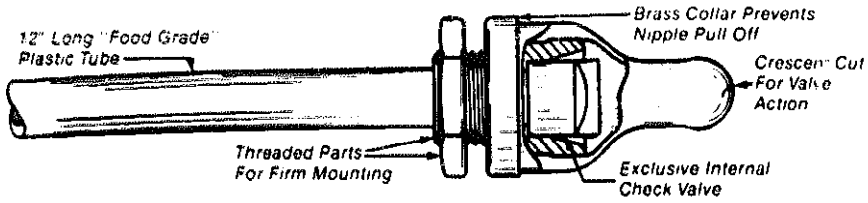
Custom Build Your Own Feeder

Many companies offer the parts for fabricating a feeder at home. . .
K & K Mfg.

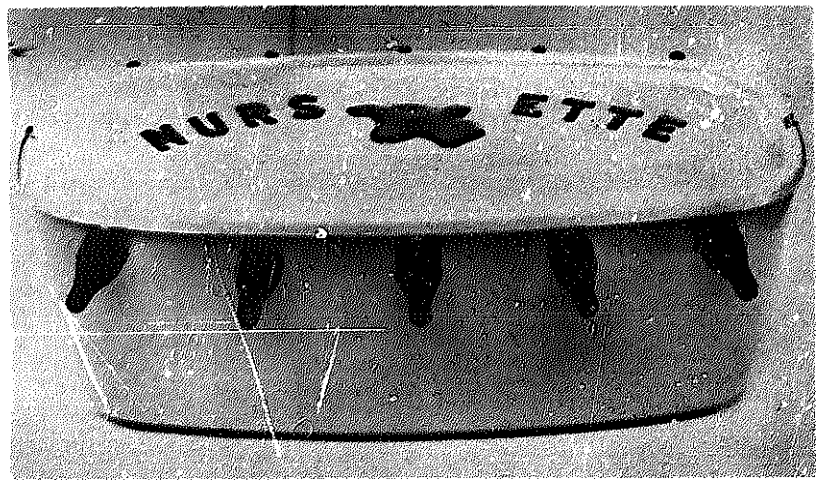


Cut a 7/8" hole in a suitable container and install the nipple and tube assembly best suited to your needs.

ASSEMBLY FEATURES:



. . . or as a preassembled unit.
K & K Mfg.



They carry shears.

R.A. Lister Agricultural, Ltd.
Dursley
Gloucestershire GL 11 4HS, U.K.

Electric- or engine-powered sheep shears are available.

Self-Sufficiency and Small-Holding Supplies
The Old Palace, Priory Road
Wells, Somerset BA5 ISY, U.K.

Shears and shepherd's crooks are available.

Ubungo Farm Implements Mfg. Co.
P.O. Box 2669
Dar-Es-Salaam, Tanzania

They carry shears.

NORTH AMERICAN SOURCES OF HOG SUPPLIES

Belknap, Inc.
P.O. Box 28
Louisville, KY 40201

They have feeders, holders, and marking equipment.

Brower Mfg. Co.
640 S. Fifth St.
Quincy, IL 62301

Hog-holding crates, farrowing pens, and pig brooders are available.

Countryside Catalog
Rt. 1, Box 239
Waterloo, WI 53594

They handle harnesses.

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

They offer holders, feeders, waterers, and marking equipment.

Glen-Bel Enterprises
Rt. 5
Crossville, TN 38555

They carry feeders.

K & K Mfg., Inc.
Rogers, MN 55374

They have a nurse-ette piglet feeder.

Marting Mfg.
Washington Court House, OH 43160

They carry a large variety of feeders, waterers, hog houses, holders, oilers, and scales.

Montgomery Ward
1000 S. Monroe St.
Baltimore, MD 21232

They handle feeders, waterers, holding crates, and farrowing stalls.

Nasco Agricultural Science
901 Janesville Ave.
Fort Atkinson, WI 53538

Marking equipment, castrators, holders, feeders, waterers, and scales are available.

New Delphos Mfg. Co.
Delphos, OH 45833

Feeders are available.

Winona Attrition Mill Co.
1009 W. Fifth St.
Winona, MN 55987

They have creep feeders.

INTERNATIONAL SOURCES OF HOG SUPPLIES

Agromet Motoimport
00-950 Warszawa, ul.
Przemyslowa 26, Poland

Waterers and farrowing cages are available.

Dalton Supplies, Ltd.
Nettlebed, Henley on Thames
Oxon, U.K.

They have weighbands.

PAL, Ets. P. Lecieux & Cie
rue du Riez
59112 Annoeullin, France

They offer feeding equipment, waterers, and farrowing pens.

Productions Master S.A.
Apartado Postal 74-057
Calzada de Tlalpan 1606
Mexico 13, D.F.

They have feeders and waterers.

Self-Sufficiency and Small-Holding Supplies
The Old Palace, Priory Rd.
Wells, Somerset BA5 1SY, U.K.

They carry tethering equipment and harnesses.

SOURCES OF BEEKEEPING EQUIPMENT

Dadant and Sons, Inc.
Hamilton, IL 62341

They have beekeeping equipment and supplies for honey production.

Glen-Bel's Country Store
Rt. 5
Crossville, TN 38555

They also have beekeeping equipment and supplies for honey production.

The Walter Kelly Co.
Clarkson, KY 42726

They have a variety of equipment, supplies for honey production, and books.

Parowan Honey & Mfg. Co.
P.O. Box 305
Parowan, UT 84761

They offer extracting equipment for large or small beekeeping.

The A.I. Root Co.
623 W. Liberty St.
Medina, OH 44256

There are a variety of equipment and supplies for honey production, books, and a magazine called *Gleanings in Bee Culture.*

Sears, Roebuck & Co.
Farm & Ranch Catalog

Beekeeping equipment and supplies for honey production can be ordered.

Sunstream Bee Supply Center
P.O. Box 225
Eighty Four, PA 15330

A variety of beekeeping equipment, honey production supplies, and books are available.

Bee Flat Scale

An interesting production connected with beekeeping is the Bee Flat Scale Kit. This small kit contains all the hardware necessary to construct a permanent scale under the beehive, allowing the beekeeper to easily check on honey production in all seasons with a minimum amount of work.

Bee Flat Scale Company
Route 4 Box 65-F
Reedsport, OR 97467

The Walter Kelly Co.
Clarkson, KY 42726

They have a variety of equipment, supplies for honey production, and books.

Parowan Honey & Mfg. Co.
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Bee Flat Scale Company
Route 4 Box 65-F
Reedsport, OR 97467

They have feeders, holders, and marking equipment.

Brower Mfg. Co.
610 S. Fifth St.
Quincy, IL 62301

Hog-holding crates, farrowing pens, and pig brooders are available.

Countryside Catalog
Rt. 1, Box 239
Waterloo, WI 53594

They handle harnesses.

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

They offer holders, feeders, waterers, and marking equipment.

Glen-Bel Enterprises
Rt. 5
Crossville, TN 38555

They carry feeders.

K & K Mfg., Inc.
Rogers, MN 55374

They have a nurse-ette piglet feeder.

Marting Mfg.
Washington Court House, OH 43160

They carry a large variety of feeders, waterers, hog houses, holders, oilers, and scales.

Montgomery Ward
1000 S. Monroe St.
Baltimore, MD 21232

They handle feeders, waterers, holding crates, and farrowing stalls.

Nasco Agricultural Science
901 Janesville Ave.
Fort Atkinson, WI 53538

Marking equipment, castrators, holders, feeders, waterers, and scales are available.

New Delphos Mfg. Co.
Delphos, OH 45833

Feeders are available.

Winona Attrition Mill Co.
1009 W. Fifth St.
Winona, MN 55987

They have creep feeders.

INTERNATIONAL SOURCES OF HOG SUPPLIES

Agromet Motoimport
00-950 Warszawa, ul.
Przemyslowa 26, Poland

Waterers and farrowing cages are available.

Dalton Supplies, Ltd.
Nettlebed, Henley on Thames
Oxon, U.K.

They have weighbands.

PAL, Ets. P. Lecieux & Cie
rue du Riez
59112 Annoeullin, France

They offer feeding equipment, waterers, and farrowing pens.

Productions Master S.A.
Apartado Postal 74-057
Calzada de Tlalpan 1606
Mexico 13, D.F.

They have feeders and waterers.

Self-Sufficiency and Small-Holding Supplies
The Old Palace, Priory Rd.
Wells, Somerset BA5 1SY, U.K.

They carry tethering equipment and harnesses.

SOURCES OF BEEKEEPING EQUIPMENT

Dadant and Sons, Inc.
Hamilton, IL 62341

They have beekeeping equipment and supplies for honey production.

Glen-Bel's Country Store
Rt. 5
Crossville, TN 38555

They also have beekeeping equipment and supplies for honey production.

The Walter Kelly Co.
Clarkson, KY 42726

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Parowan Honey & Mfg. Co.
P.O. Box 305
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Farm & Ranch Catalog

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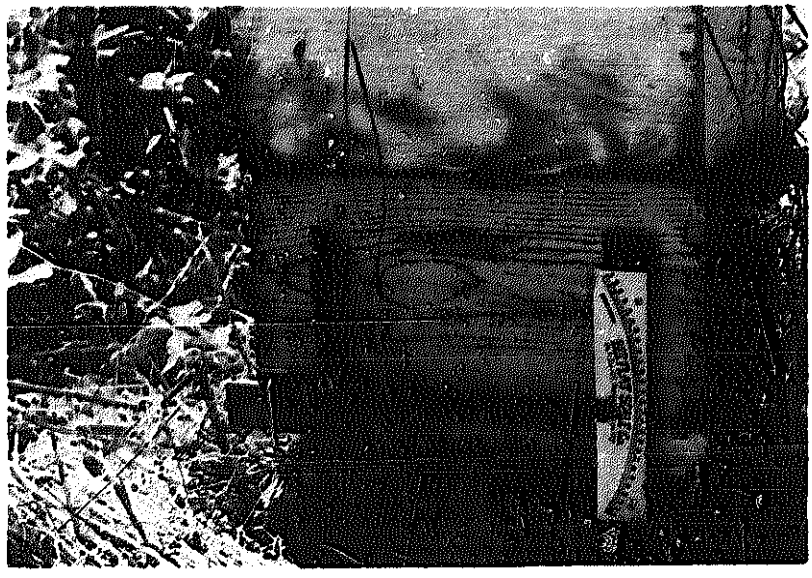
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Bee Flat Scale Company
Route 4 Box 65-F
Reedsport, OR 97467



The Bee Flat Scale
Bee Flat Scale Co.

-12- Tools for Fish Farming

edited by Nancy J. Moore

The uses of a farm pond are as varied as its owners. For some, ponds perform the vital function of providing water for home and livestock. To many people, the pond is a great source of recreation and relaxation—swimming, boating, and fishing in summer, and skating in winter. The pond serves as a catch basin for pasture runoff during rainstorms and is often the only water source for a range area in the event of fire. Insurance companies have been known to lower premium costs for owners of farm ponds.

Pond water is particularly rich in organic material when it contains fish and algae. Resourceful farmers can use this nutrient-rich water for crop irrigation, and benefit from the fertilizer boost as well. The extra bit of work and planning necessary for a successful farm pond is easily offset by these benefits.

AN INTRODUCTION TO AQUACULTURE

by William O. McLarney, Ph.D.

The best argument for aquaculture is based on the ever-increasing need for protein foods. Fish and aquatic invertebrates are efficient food converters, capable of producing more protein per unit area from the same amount of food than their warm-blooded counterparts. The quality of protein is the highest available from animals and is the lowest in fat content.

The farm pond is usually stocked with largemouth bass and bluegills, and is designed to provide sport fishing with food as a fringe benefit. Even when managed with recreation in mind, the farm pond has been shown to produce a substantial amount of edible fish and, it is my belief that, properly managed, it could become a really significant factor in the nourishment of many families.

More than a few American farmers have made the logical transition from eating pond fish to fish culture for the express purpose of food production, often on a commercial scale. They are usually encouraged to go into farming rainbow trout or channel catfish. The former species has produced fantastic yields but requires a large and dependable supply of water at a constant temperature—a condition which can be met by only a few landowners. Catfish farming is more amenable to most farmers as it can profitably be carried out in warm, still water.

Almost all trout farmers use antibiotics, not only in disease treatment, but as a prophylactic measure in their stock's diet. Use of antibiotic feeds is increasing in catfish culture, and many farmers also apply chlorinated hydrocarbon herbicides as a matter of course. Researchers at the New Alchemy Institute in Falmouth, Massachusetts, and at Rodale Resources Incorporated in Emmaus, Pennsylvania, are seeking alternatives, however.

Trout and catfish farming in the United States is further characterized by monoculture and heavy feeding. The latter will almost always increase production and may be necessary in large-scale commercial fish culture, but it certainly is not necessary to produce yields appropriate for personal, family, or community use. Asian fish culturists produce thousands of pounds of food fish which derive their nutrients essentially through organic pond fertilization or enrichment from surrounding farmland, through cut grass, vegetable tops, or other such inexpensive feeds. Similar systems are beginning to evolve in Africa, where considerable success has been achieved with community fish ponds stocked chiefly with herbivorous tilapia.

The direct or indirect utilization of organic wastes by fishes is by no means the only way in which fish ponds can contribute to the recycling capacity of a farm's ecosystem. Excess fish or fish too small for human consumption may be com-

posted or fed to other livestock such as hogs or chickens. Under certain conditions, metabolic wastes from fish and shellfish may be applied beneficially to vegetable crops without harvesting the fish.

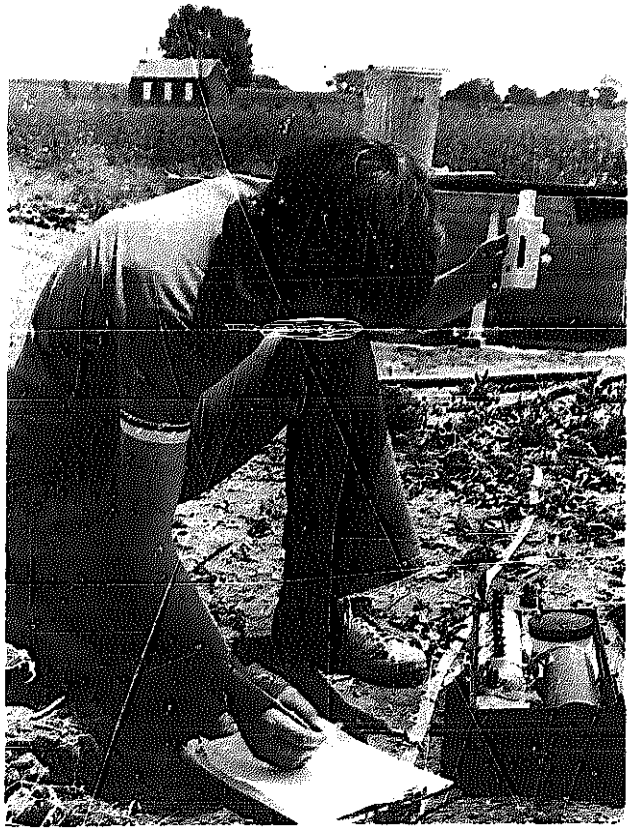
Polyculture is a widely applicable technique, with high yields being its most obvious benefit. The Chinese employ a highly refined polyculture technique which supplies them with a substantial supply of fish as it recycles their waste products and fertilizes their gardens. They build their latrines and animal shelters with slatted floors over the pond for organic wastes to fall through and supply the pond with a nutrient source. The pond becomes rich with algae feeding on the manure and provides a foundation for a complicated food chain to build upon. Algae- and manure-rich water is syphoned off to irrigate the garden and fertilize it at the same time.

A further benefit of polyculture includes providing the farmer with greater economic stability. (If one crop fails; there's always something else.) It also reduces the likelihood of a disease or pest destroying the entire crop, with the consequent temptation to use chemical poisons.

It would seem, then, that American food growers at all levels of the economy should not only consider taking up aquaculture, but should also be busy developing modern American analogs of the traditional Oriental pond polyculture systems. When integrated with similar practices on the land, such systems have the potential to revolutionize American agriculture—organically.

WATER QUALITY

When employing intensive fish culture techniques, it is advisable to monitor the water quality. A thermometer is a must for all pond owners, but the intensive aquaculturist must also worry about dissolved oxygen and ammonia content in water. Too much ammonia or too little



Frequent testing of water quality for excesses of ammonia or any oxygen deficiency will warn the fish farmer of problems before they become critical.

oxygen quite often will result in fish kills. And with intensive fish culture, small deficiencies or excesses can rapidly reach dangerous proportions.

There are several companies which manufacture chemical testing kits for under $50, and one company manufactures a meter for measuring dissolved oxygen for a bit over $100.

Several companies manufacture water test equipment, but it is generally designed for precise research work, so prices tend to be high. For example, laboratory-quality oxygen meters, accurate to tenths of a part per million, start at $500. However, the Garcia is designed for fishermen, is less accurate but accurate enough, and costs a little over $100 (1977 price).

The other option for farm pond water testing is to use chemical kits. They require more time, to mix solutions and add chemicals to water samples, but they are much less expensive. The chemicals are premeasured in little packets called pillows to make the procedure as expedient and simple as possible. Chemical test kits are available to measure dissolved oxygen, pH, nitrogen ammonia, hardness, CO_2, and many other factors.

Garcia D.O. Meter

The Dissolved Oxygen meter is available from:
Garcia Dissolved Oxygen Meter
329 Alfred Ave.
Teaneck, NJ 07666

Test Kits

Chemical test kits are available from:
La Motte Chemical Products Co.
P.O. Box 329
Chestertown, MD 21620

Hach Chemical Co.
P.O. Box 389
Loveland, CO 80537

AERATION

Most fish deaths occur because of an oxygen deficiency. Excessive algae and weed growth may rob ponds of oxygen, and the ammonia produced by fish waste products seriously affects water quality. Decomposing plant and animal materials may also contribute to oxygen loss and ammonia buildup. Aeration equipment offers relief from oxygen deficiency and excess ammonia problems.

Aerators can be divided into two main categories, mechanical aerators and agitators which transfer atmospheric oxygen into water, and diffusers, which are tubes that introduce oxygen bubbles into the water under its surface. Anyone who has seen an aquarium filter in operation knows how this type of aerator works.

Floating mechanical aerators use a pump to spray sheets of water above the pond's surface. This spraying action causes the water to absorb oxygen, aids in the removal of carbon dioxide and ammonia, and also may slightly lower water temperatures. Agitators are usually equipped with paddles which stir the water, causing it to oxygenate at the surface.

These positive features are clouded by a few disadvantages as well. Floating aerators and agitators should not be in operation while anyone is boating or fishing because they present an electrical hazard. They also obstruct the natural look of the pond. Some companies have manufactured aerators with decorative spray patterns in an effort to turn this negative feature into an attribute.

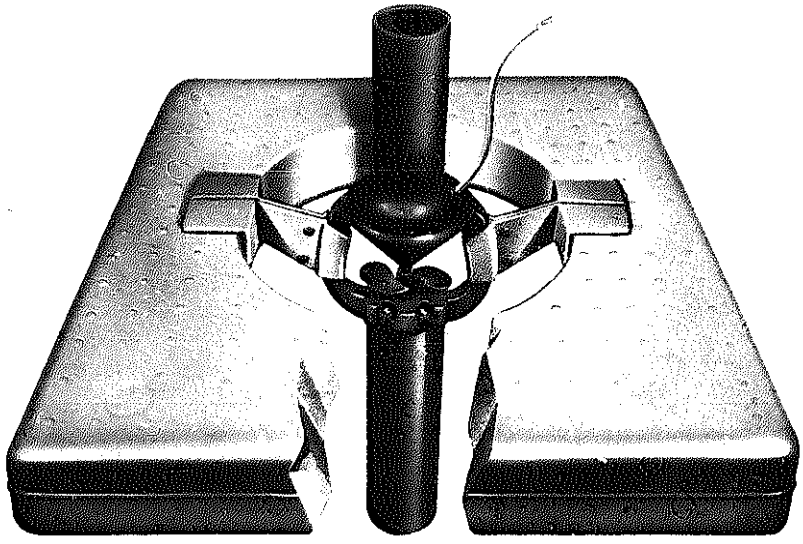
Diffusers, on the other hand, oxygenate the water while submerged, so they don't interrupt the aesthetics of the landscape or prohibit swimming or boating. Because of the equipment necessary for installation, such as air compressors and air pumps, diffusers are generally a more-expensive enterprise. Operation costs are generally higher because of a higher power requirement.

SOURCES OF AERATORS

Air-o-Lator

A floating mechanical aerator, the Model AF-14 has a totally submersible 1/3 h.p. (115 volts, 7 amps under full load), stainless steel, electric motor which moves 350 gallons of water per minute, and comes with a 50-foot cord. Shipping weight: 35 pounds.

Air-o-Lator (Div. of Roycraft Industries)
8100 Paseo St.
Kansas City, MO 64131



A cross section of the Air-o-Lator illustrates the position of the pump and impeller within the supportive float of a mechanical aerator.
Air-o-Lator

Aquacharger

This unit is a ceramic diffuser-aerator. The manufacturer states that a single unit is sufficient to aerate a 1- to 2-acre lake 10 to 25 feet deep. The diffusing cylinder is 2.25 inches in diameter and 9.5 inches long. It will circulate water to a radius of 20 to 30 feet at the pond surface. Additional equipment needed for operation are a buried electric line with an outlet socket, a waterproof pump house on a concrete slab, an air pump, and copper tubing. Overall life of the unit is estimated at 10 years.

Environmental Management & Design, Inc.
P.O. Box 493
Ann Arbor, MI 48107



Aquacharger Ceramic Diffuser-Aerator
Environmental Management & Design, Inc.

Aqua Puss

The Aqua Puss is an air diffuser-aerator. Air is released from the diffuser in sufficient volume to maintain turbulent uplift at a rate at which oxygen transfer can take place. The water jet propels water enough to carry it above the water surface, making a rise in the pond. The water then flows back upon itself and is converted to a horizontal flow 360 degrees around the rising column.

Schramm, Inc.
901 E. Virginia
West Chester, PA 19380

Boatcycle Company

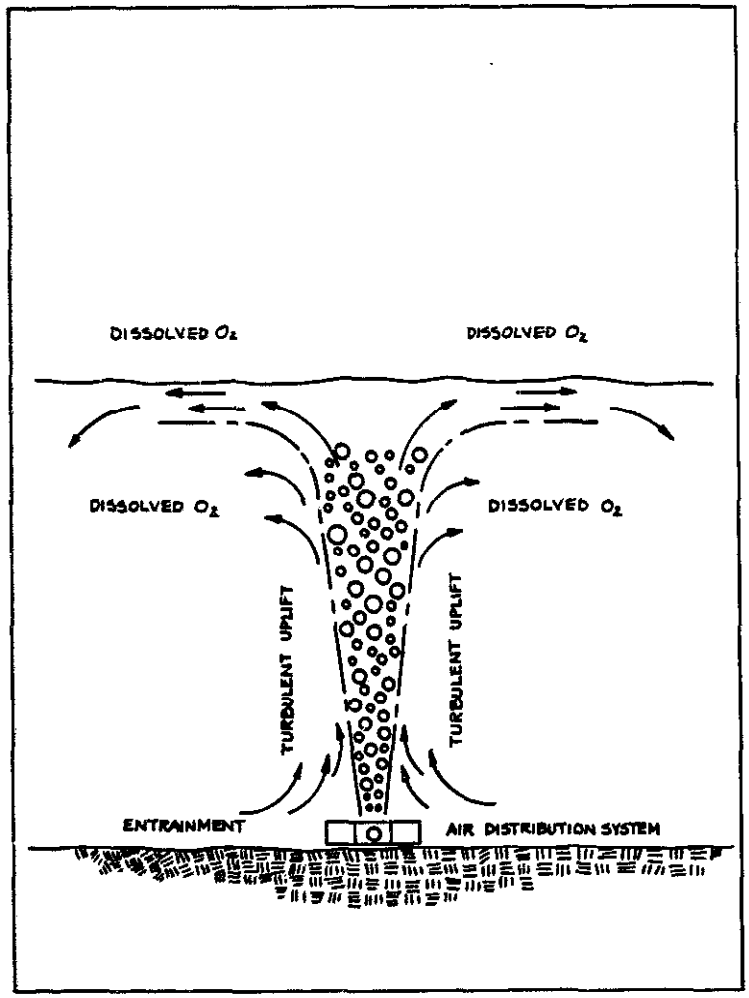
They are agitation equipment manufacturers. The Big Bull agitator has a 110-volt, ⅓ h.p. motor with a one-year warranty against defective materials and workmanship, provided all repairs have been done by the manufacturer.

Boatcycle Co.
P.O. Box 494
Henderson, TX 75652

Crescent Agitators

Crescent manufactures agitators in a variety of sizes for everything from small hauling and holding tanks to outdoor ponds. Both indoor and outdoor models are available.

Crescent Mfg. Co.
P.O. Box 3303
Fort Worth, TX 76105



Air distribution system of a diffusing aerator.

Air Jet Aerator

The makers of the Air Jet manufacture various kinds of agitation equipment. In this aerator, air is drawn down through a tube to a propeller and broken up into tiny bubbles. The water level will not alter the effectiveness of the unit. Models for both transport and pond aeration are powered by 110-volt, ⅓ h.p., fan-cooled, continuous-duty ball bearing motors.

Commerce Welding & Mfg. Co., Inc.
2200 Evanston St.
Dallas, TX 75208

Fresh-Flo

In this centrifugal action aerator, a propeller-impeller draws water into the unit and initiates a tremendous force. Water is passed through slots above the water line, and sheets of water are sandwiched with open air. This aerator is mounted on pipes, floats, or overhead installations and provides a continuous circulation process.

Fresh-Flo Corp.
Rt. 1
Adell, WI 53001

GenAIRator

This diffuser-aerator will aerate and circulate 6,000 gallons of water per hour (100 gallons per minute), and add 50 pounds of oxygen to the water per day. The ¼ h.p. motor has a thermo protector which shuts the motor off

temporarily during periods of low voltage or current shortages. There is no float, standpipe, or overhead support; it needs no adjustment to different lake levels. This model poses no hazard to boaters or swimmers, and it has a one-year guarantee.

Kembro, Inc.
P.O. Box 205
Meguon, WI 53092

McDonald Oxidator

Unlike many hanging aerators, water level is not critical with this agitating oxidator. It operates effectively when immersed in 8 to 12 inches of water. Aeration occurs at the surface by an agitating blade and at the bottom of the oxidator by an air rotor. The unit is engineered to aerate more with less agitation.

McDonald Bait Co.
Rt. 2, Box 300
Erin, TN 37061

Micro-por

This air diffuser-aerator consists of ABS thermoplastic tubing containing approximately 1,000 microscopic holes per linear foot. As air is introduced through the tubing at low pressure, it seeps out through these tiny pores along the entire length of the Micro-por pipe. Available in 100-foot coils or in 5-foot straight lengths with ½ inch male thread adapters.

Micro-por, Inc.
P.O. Box 278
Colwich, KS 67030

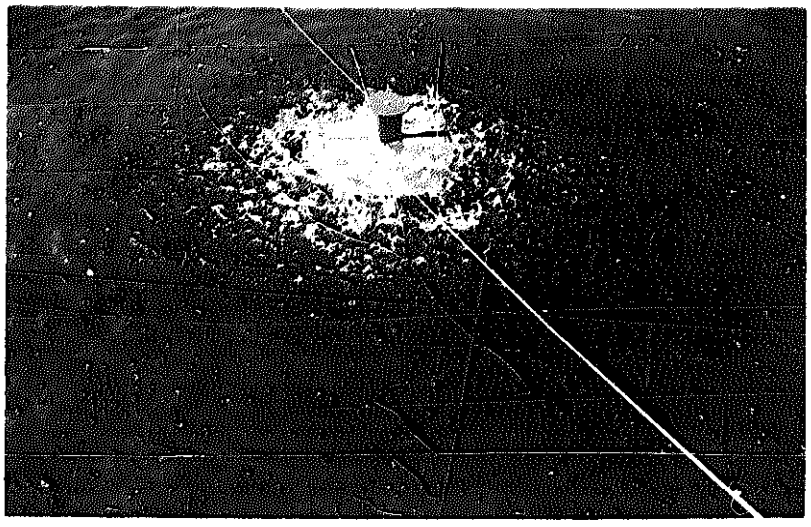
P.J. Minneau

Floating and submersible aerators are available from this company in the following sizes:

1. A 5 inch unit with a ⅓ h.p. electric motor which aerates 100 gallons per minute at ½ cent per hour;
2. A 5 inch unit with a ½ h.p. electric motor which aerates 200 gallons per minute at 1 cent per hour;
3. A 5 inch unit with a 1 h.p. electric motor which aerates 400 gallons per minute at 2 cents per hour; and
4. A 5 inch unit with a 2½ h.p. gasoline motor which aerates 500 gallons per minute at 10 cents per hour.

A 1½ inch pipe is needed for installation, its length depending upon the water depth and the depth it must be driven into the bottom to be firmly situated (submersible type). (Electrical costs were calculated in 1977).

P.J. Minneau Machine Co.
Lime Kiln Rd., Rt. 6
Green Bay, WI 54301



Floating mechanical aerators, like this Otterbine Mechanical Aerator, may need to be held in place by mooring cables.

Otterbine® Aeration Systems

These compact 1, 2, 3 and 5 horsepower floating mechanical aerators are designed to improve water quality in fish ponds by increasing the supply of dissolved oxygen available to the fish and by mixing the water to distribute dissolved oxygen to various depths.

With aeration, fish can be stocked more heavily, reach eating size faster, and are less vulnerable to diseases and parasites.

Otterbine aerators are installed by floating them into position in the pond, and mooring or anchoring them in place. An underwater power cable leads to on-shore electrical service. The 1 and 2 horsepower models require either 115 or 230 volt single-phase power; the 3 and 5 horsepower models require 230 or 460 volt three-phase power.

All Otterbine aerators are warranted conditionally against defects in materials and labor for one full year from date of delivery.

Rodale Resources Inc.
576 North St.
Emmaus, PA 18049

Vulcan Aerator Company

Vulcan's model No. 12 has a 12-volt, ball bearing, totally enclosed motor, with continuous-duty, replaceable brushes. Domes are available for splash-free operation, and it requires 3½ amps at half-paddle. Model No. 10 has a 1.5-amp, alternating current motor which operates at a slower speed.

Vulcan Aerator Co.
N. 113, W. 18830 Carnegie Dr.
Germantown, WI 53022

Xodar Corporation

Xodar's Model 360 is a submersed aeration diffuser. The air flow volume is very low in order to achieve sufficient discharge pressure to produce an effective bubble swarm for the desired maximum oxygen-to-water transfer.

Xodar Corp.
Powder Hill Dr.
Lincoln, RI 02865

FEEDING

Two conditions encourage the use of supplemental feeding of farm pond fish: when the stocking density is higher than what would occur naturally and thus exceeds the natural food supply, and when an increased growth rate is desired. High-protein, pelleted commercial feeds satisfy both conditions and are available at most local feed stores.

Feed pellets are in either floating or sinking form. Floating pellets permit the farmer to watch his fish feeding. He can check growth as well as gauge what amount to feed. The activity with which fish feed is indicative of their health; healthy fish feed actively.

Sinking pellets insure that smaller, more timid fish are fed also. Every fish will eat, not only the big, aggressive fish cruising the water surface. Often pond owners use a combination of floating and sinking feed to reap the benefits of both. Feeding habits are species-specific. Thus, fish farmers should select feed according to recommendations for the variety they are raising.

Fish feeds come with different protein ratios; selection depends upon how extensive the feeding program is. If commercial feed is used only to supplement the fishes' natural diet, a lower protein ratio (25 to 30 percent) is used. If it is the major portion of the diet, then a higher protein ratio (30 to 40 percent) is recommended.

Many pond owners feed their fish by hand. This method is economical, but requires that the owner always be present at feeding time. Purchasing an automatic commercial feeder can easily involve an investment of $100 or more. The simplest feeder is a floating ring which merely confines food to one spot rather than having it float all over the pond. A design carrying the floating ring idea one step further is described in the following build-it-yourself plan. If you have decided to feed by hand, this feeder can make the venture easier while utilizing feed more effectively.

BUILD-IT-YOURSELF FEEDER

This feeder can be used with both sinking and floating feeds. While sinking pellets drop into a sloped screen tray, floating feed remains



A simple feeder will cut down on waste by preventing scattering.

FISH FEEDER

Materials Required

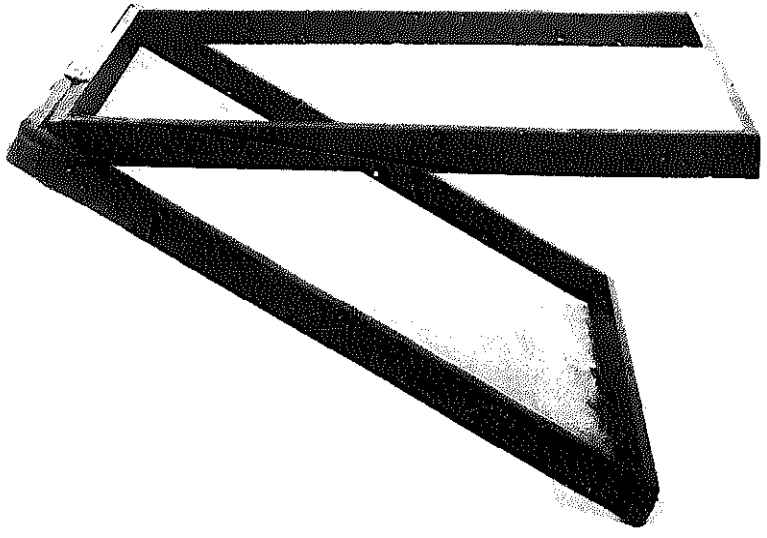
QTY	SIZE & DESCRIPTION	PURPOSE
2	¾" x 24" x 2¼" Pine	Frame
2	¾" x 38" x 2¼" Pine	Frame
2	¾" x 21" x 2¼" Pine	Floating
2	¾" x 37" x 2¼" Pine	Frame
1	44" x 28" Aluminum or Plastic Screening	Tray Bottom
1	8" Strap Hinge	
14	2"–#8 Wood Screws	
	Staples or Tacks	
	Marine Varnish	

confined within a floating wooden square. Surface-feeding fish 'boil' the water as they scramble for food; fish occupying different feeding niches are satisfied with food distributed at different depths on the screen. It is necessary to weight the screened frame with a brick to keep it submerged.

Marine varnish or paint on the frame prevents the wood from rotting, and placing chicken wire over the floating frame keeps birds and other animals from stealing feed. Training fish to feed at one spot will allow you to watch them as they feed. Also, with fish congregated in one spot, harvesting procedures may be simplified.

Pretreat wooden frames with marine varnish before using wood screws in assembling the two frames. One frame will be 21 by 37 inches, the other 24 by 40 inches. The larger frame has screening stretched beneath it, stapled or tacked in place. Use the strap hinge to join the two frames so that the smaller of the two is inside the larger.

For turbulent water, you may wish to make the floating bracket smaller so water currents don't carry feed outside the screen.



Build-It-Yourself Feeder

SOURCES OF COMMERCIAL FEEDERS

A number of commercial feeders are available which automatically dispense feed at timed intervals, while others feed by demand.

E-Z Feed

The E-Z Feed is an automatic feeder with a time-controlled dispensing apparatus. Any type of dry food can be used, and the hopper will hold 40 to 50 pounds. This amount should be sufficient for 6 to 8 weeks for a 1- to 2-acre pond. Suggested installation is over the deepest water up to but not exceeding a depth of 10 feet. Larger or smaller hoppers are available upon request. If no electricity is available at the pond



E-Z Feed Feeder
E-Z Feed Co.

site. E-Z Feed offers a direct current model equipped with a 12-volt battery.

E-Z Feed Co.
P.O. Box 97
Morrisville, NC 27560

Nielsen Model 5-0101

This is an automatic feeder with a 100-pound capacity hopper which has an adjustable gate to control food flow. It is electrically powered by a 115-volt, 60-cycle, alternating current motor which normally draws 3.6 amps. Adjustable mounting brackets are available for installation. Feed dispersion patterns can easily be adjusted manually.

Nielsen Metal Industries
8501 Portland Rd. NE
Salem, OR 97303

Poirot Farm Industries

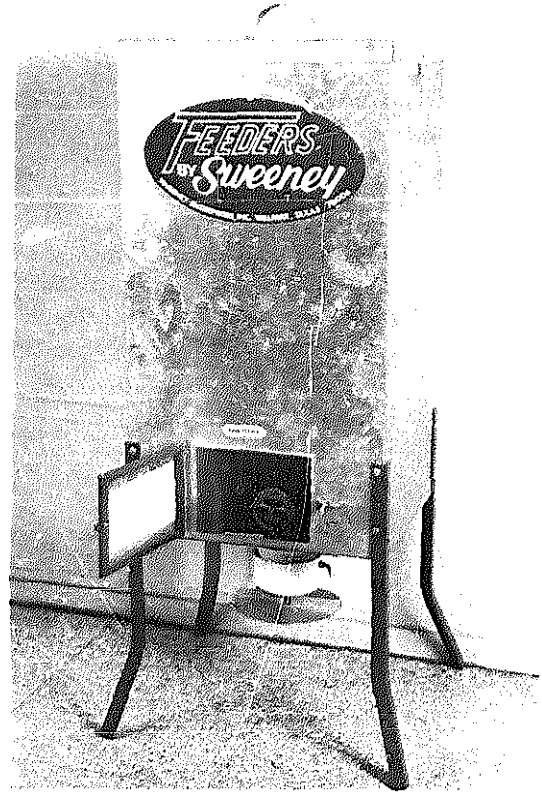
This company markets an automatic, floating, gravity-operated fish feeder which does not require electricity to operate. It is available with or without a float, and in 100- and 200-pound hopper sizes. The unit is lightweight and can easily be moved to any section of the pond, as it does not require an electrical outlet.

Poirot Farm Industries
Golden City, MO 64748

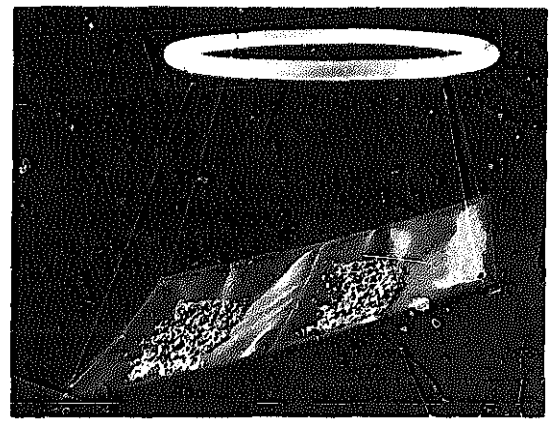
Sweeney Enterprises, Inc.

Automatic feeding systems are offered here with either 100- or 200-pound hopper capacities and adjustable feed dispersion patterns and flow rates. One model is a front-drop feeder (HF 1). All feeders are battery powered and equipped with a rechargeable dry battery and a DFT-1 Timer. Possible methods of installation include: standing the feeder on its short legs or purchasing extension legs, hanging it from cables and cross arms, or mounting it on a float.

Sweeney Enterprises, Inc.
Rt. 2, Box 145G
Boerne, TX 78006



Sweeney Feeder
Sweeney Enterprises, Inc.



Farm Pond Harvest Feeder
Farm Pond Harvest

Farm Pond Harvest Bluegill Feeder

This feeder utilizes both floating and sinking fish feeds. A floating ring contains floating

feed, and a plastic feeding tray suspended under this floating ring holds the sinking feed. This tray prevents the sinking feed from falling to the bottom of the pond. Bluegill may teach bass to eat from the feeder, helping with the harvest of bass. This feeder and feed are available from your local Purina dealer. If they do not have feeders contact:

Farm Pond Harvest
P.O. Box AA
Momence, IL 60954

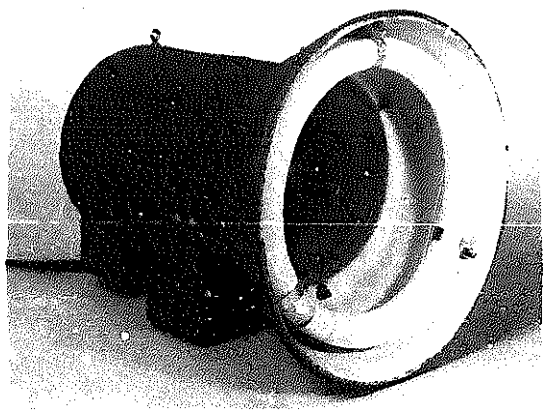
BUG LIGHTS

Another type of feeder is the bug light, a device which attracts insects by fluorescent lighting. A fan pulls bugs into the water, or a blade cripples their wings, causing them to fall into the water. But depending upon your location, bug lights are often effective only during summer months when insects are prevalent.

SOURCES OF BUG LIGHTS

Will-o'-the-Wisp

This model is an adaptation of the yard bug light; it's an ultraviolet light which attracts insects and is equipped with a fan to blow them down into the water. The shell is made of fiberglass, and the black light is a 32-watt circular fluorescent tube connected to a small electric motor with a fan blade. The only maintenance needed is occasional cleaning and, possibly, replacement of the light bulb. Operating costs (in 1977) are less than 10 cents per day.



Will-o'-the-Wisp Bug Light
Hedlunds of Medford, Inc.

Hedlunds of Medford, Inc.
P.O. Box 305
Medford, WI 54451

Bug-Eater and Security Light

This model is controlled by a photo cell which turns it on at dusk and off at dawn. It is easily plugged into any standard 110-volt outlet, and a direct current operating unit will permit operation where alternating current is not available. A specially designed wire blade rotates rapidly and cripples insects attracted to the light, scattering them into the water below. The unit causes no insect buildup or odor, and operating costs are less than 1 cent per day (in 1977).

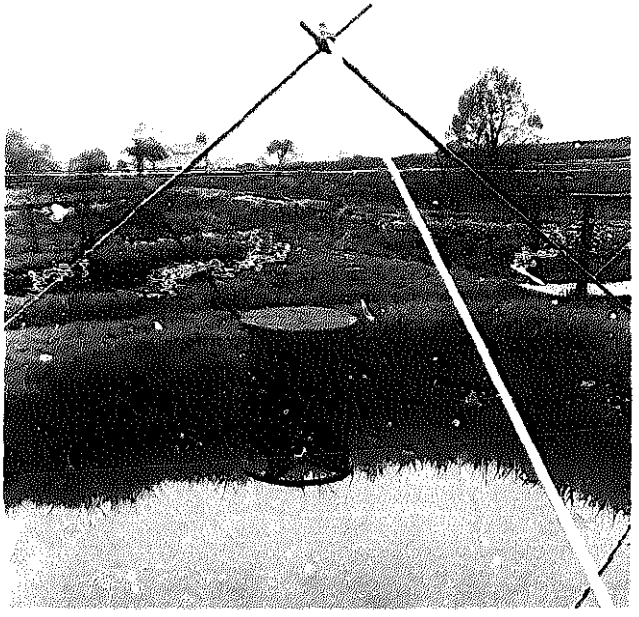
Southeast Equipment Co.
P.O. Box 6
Enigma, GA 31749

INSECTS . . . AN UNTAPPED RESOURCE

by Andy Merkowsky

Insects are a natural resource man has yet to utilize to full potential. For most people, bugs are bothersome pests, but viewed differently, they are an excellent source of protein. The protein content of insects is high; some contain more than 60-percent protein. They live almost everywhere and have tremendous reproductive ability.

The squeamishness of most Western societies prohibits human consumption of insects. A more easily accepted method of utilizing insects is to recycle them through other animals. They can be incorporated into pelleted fish feeds or dropped directly into the pond with the aid of a bug light suspended over the pond. Fish congregate under these traps to feed. The high protein content of the



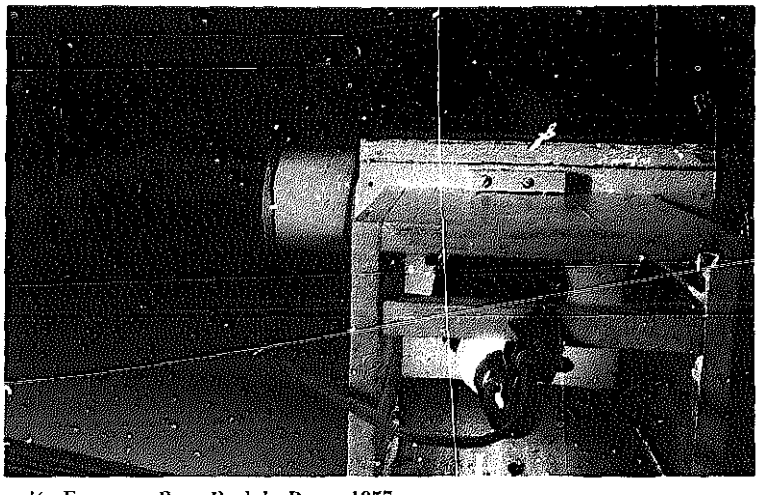
Suspending an easily constructed insect trap over a pond transforms insect pests into fish food.

insects makes for better growth rates in the fish, and as an added benefit, the fish will be easier to catch because they are congregated in one area.

Several types of insect traps have been developed, and companies are now marketing them. Although commercial traps work well, they are very expensive. Homemade traps are cheaper to build and work about as well as commercial models.

DICK'S BUG MACHINE*

Originally designed by Dick Geddes of Winsted, Connecticut, this insect trap was used to supplement his chickens' diet. With only minor alterations, this insect trap can be suspended over a pond to effectively feed fish.



Dick's Bug Machine

* Reprinted from *Build It Better Yourself*. Emmaus, Pa.: Rodale Press, 1977.

MATERIALS

Wood

1–2′ x 4′ sheet, ¾″ exterior plywood or

Sides: 4 pcs. 12″ sq.
End: 1 pc. 12″ x 13½″
Sides: 4 pcs. 8″ sq.

1 pc. 1″ x 1″ x 2″ or

Brace: 1 pc. 1″ x 1″ x 8″
Mounting block: 1 pc. 1″ x 1″ x 4″

Hardware

6d nails

3–½″ #6 screws

1 light bulb clamp and waterproof socket

1–10-watt light bulb

4–1″ #6 screws

Miscellaneous

1 electric fan, approx. 4½″ intake

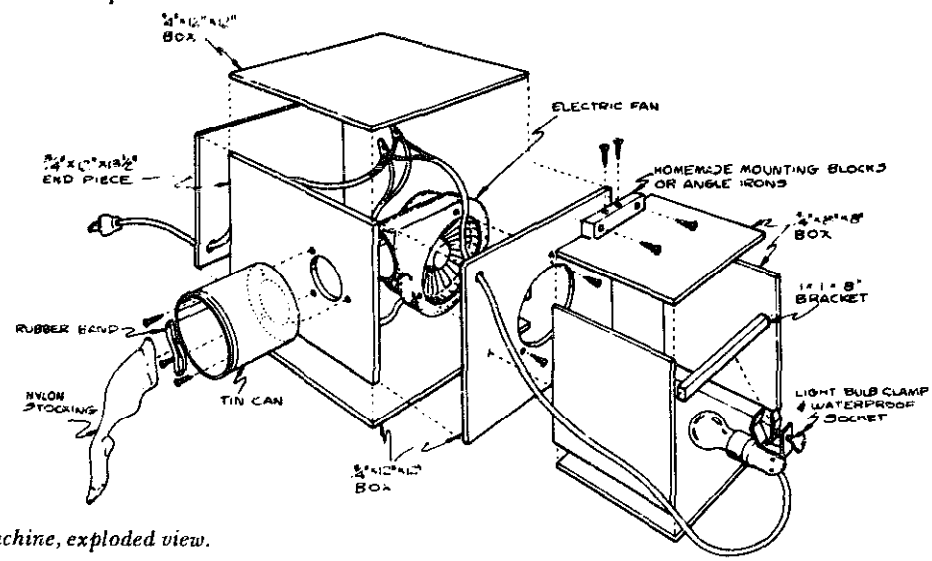
1 tin can

1 nylon stocking

1 heavy rubber band *OR* 1 elbow tube

CONSTRUCTION

1. From ¾ inch plywood, cut four 12 inch square pieces and a piece 12 inches by 13½ inches. Nail the square pieces together, forming an open-ended box, using 6d nails.
2. Measure the diameter of the fan intake and cut a hole that size in the center of one side of the box. Mount the fan in the box, the intake against the hole cut for it, the exhaust directed out one of the open ends of the box.
3. Place the remaining piece of plywood against the open end through which the fan exhausts. Mark the location and size of the exhaust on the plywood, then remove the plywood and cut out the exhaust hole. Next, cut a similar-sized hole in the bottom of the tin can and secure it over the exhaust hole with three ½ inch #6 screws. Finally, nail the plywood to the box, using 6d nails.
4. Cut four 8 inch square pieces of ¾ inch plywood. Nail them together forming another open-ended box. Cut an 8 inch length of 1 by 1. Nail it across one open end of this box, so the light socket can be clamped to it, with the bulb inside the box.
5. Secure the light box to the fan box, using small corner irons or a homemade mounting, as shown in the photo.



Dick's Bug Machine, exploded view.

6. To trap and collect insects, slip a nylon stocking over the exhaust pipe and secure it with a stout rubber band.
7. For an automatic feed of insects into your pond, replace the stocking trap with an elbow tube directed toward the water.
8. Plug in the light and fan. A 40-watt bulb will provide adequate light.

CAGE CULTURE

There are many advantages to raising fish in cages. Cage confinement means fish can be grown in streams and rapidly moving water without any fear of losing them to the natural environment. Feed waste is greatly reduced since the feeding is concentrated in a very small area. Because the movement of the fish is restricted, they do not need much feed to survive. They just eat and grow! Monitoring fish growth and health is greatly simplified, and the threat of predators is reduced. For a 100-percent harvest, the cages are simply lifted from the water—no fishing, draining, or seining (harvesting with a drag net) is necessary.



Cage culture makes use of bodies of water that are otherwise unsuitable.

CAGES: A NEW APPROACH TO FISH CULTURE

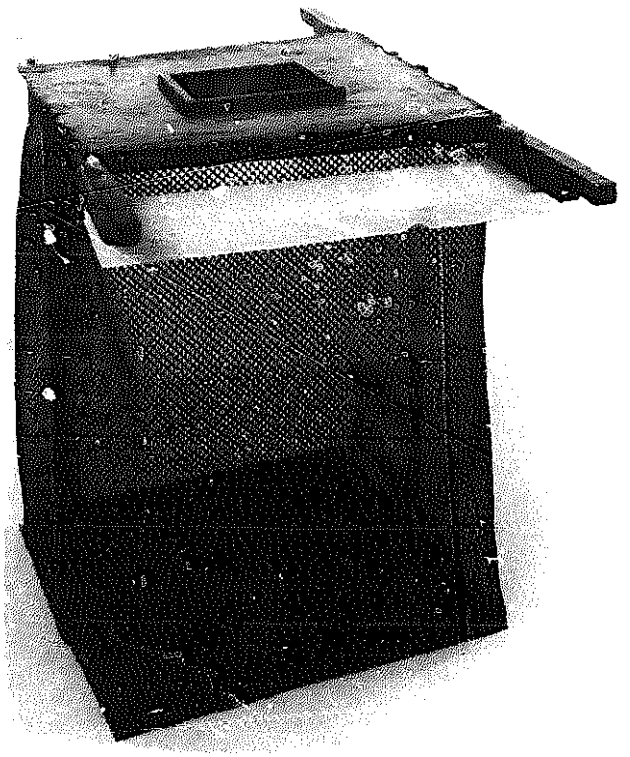
by Andy Merkowsky

Fish culture is an ancient art, but several new approaches have been developed in recent years. One of the more interesting developments is cage culture. Using this approach, the great numbers of farm ponds that would otherwise lay idle because they are without drains or contain stumps that make them impossible to seine, can now be utilized. Floating cages in these ponds can produce fish at a cost much lower than store prices for fresh fish. Cage culture does not interfere with the other pond uses; the pond can still be used for watering cattle, irrigating crops, or recreation.

Stocking rates in cages are amazingly high. For a cage measuring one cubic meter it is recommended that at least 150 fingerlings be stocked. Any less than this and fish may become territorial, resulting in fighting. Some researchers have successfully raised 500 fish per cubic meter, but a stocking density of 200 to 250 fish per cubic meter is generally suggested for most efficient use of cage space.

Cage culture is perhaps the cheapest method of raising fish because pond construction costs can be

avoided by using a farm pond already in existence. The movement of fish in cages is restricted so fish do not use as much energy, making feed costs much lower. Fish obviously are much easier to harvest, too.



An easily constructed, durable fish cage.

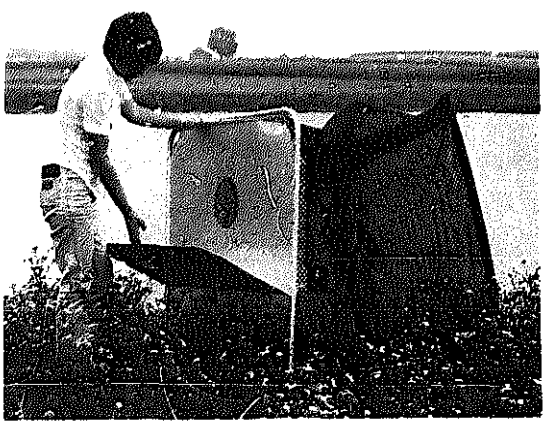
NORTH AMERICAN SOURCES OF FISH CAGES

Double-Q Cages
Inqua Corp.
P.O. Box 1325
Homestead, FL 33036

Duracraft
Duracraft
Dept. SDEB
Monticello, AR 71655

Aqua-Fab
L & M Aqua-Fab
1853 W. Commonwealth
Fullerton, CA 92633

This small company custom-builds cages to the buyer's specifications.



The Double-Q cage is available from a number of distributors.

Marinovich
Marinovich Trawl Co., Inc.
P.O. Box 294
Biloxi, MS 39533

Distributors of Fish Cages
Act One Supplies
1530 MacArthur Blvd.
Oakland, CA 94602

Aquatic Control, Inc.
P.O. Box 100
Seymour, IN 47274

Astra Chemicals, Ltd.
1004 Middlegate Rd.
Mississauga, Ontario L4Y 1M4, Canada

John B. Fitzpatrick
214 E. North St.
Dwight, IL 60420

Suppliers of Netting for Homemade Cages
Con Wed Corp.
770 29th Ave. SE
Minneapolis, MN 55414

E.I. DuPont De Nemours & Co., Inc.
Specialty Markets Div., Film Dept.
Wilmington, DE 19898

McCrary's Farm Supply
114 Park St.
Lonoke, AR 72086

C.E. Shepard Co.
P.O. Box 9445
Houston, TX 77011

HARVESTING

Any farm pond venture is only as successful as its harvesting methods. Getting the fish from the pond to the table can be approached in a variety of ways. For the sports-minded harvester, there is always the angler's approach. If the fish don't bite or if you want faster results, there are a variety of techniques which employ nets. Seining the pond and using gill nets are two efficient methods of harvesting fish all at once. Dip nets are effective for small harvests and will not injure fish.

SOURCES OF HARVESTING MATERIALS

Commerce Welding and Manufacturing Company

This company manufactures 3/16 inch, nylon mesh, double-frame dip nets with two handle sizes. The nets have 15 inch widths. Handles are available in either 12 or 24 inch lengths.

Commerce Welding & Mfg. Co., Inc.
2200 Evanston St.
Dallas, TX 75208

Crescent Manufacturing Company

Crescent manufactures small dip nets for fingerlings and minnows. The nets have 6 to 9 inch bags of 3/16 inch nylon netting or 3/8 inch net. Nets are available in widths of 10, 12, 14, 18, 20, and 24 inches with handles 10 to 20 inches long. Small-mesh nylon seines are manufactured in depths of 4 to 12 feet and mesh sizes of 1/8, 3/16 and 1/4 inch. Larger mesh seines are offered in sizes of 1/2, 3/4, 1, 1 1/2, and 2 inches and in depths of 6 to 12 feet. Seines are tarred with black net bond for added strength.

Crescent Mfg. Co.
P.O. Box 3303
Fort Worth, TX 76105

Duraframe Dipnet

Dip nets come in three shapes, lengths of 3 1/2, 5, and 6 feet, and mesh sizes of 1/16, 1/4, 3/4, and 1 inch. Seines are made to the purchaser's specifications. Nets and seines are guaranteed for a period of one year: frames are handmade, and those used in cement runways have a second metal rim to keep the net lacing from rubbing and wearing against cement walls.

Duraframe Dipnet
Rt. 2, Box 166
Viola, WI 54664

Nylon Net Company

This firm manufactures a wide variety of nets, seines, and lead sinkers.



The protective outer rim of the Duraframe Dipnet prevents the net from being damaged if rubbed against the pond wall.
DuraFrame Dipnet

Nylon Net Co.
P.O. Box 592
Memphis, TN 38103

Poirot Farm Industries

The PFI Automatic Fish Harvester models 1-A and 1-B are made of ¾ inch nylon netting tied to three 6-foot pieces of aluminum tubing. When combined with a feeding apparatus, the net will be released when almost all of the feed has been eaten. A 12-volt battery is all that is needed to power the device. Model 2-B is available for minnows and small fish. If a customer is dissatisfied with the units after three weeks, a full refund is given if the system is returned washed. The automatic lift and sensor are guaranteed for 1 year against failure.

Poirot Farm Industries
Golden City, MO 64748

Gill Nets

Gill nets are very large, lightweight nets with mesh averaging about 3 inches. They have little application in fish farming because they catch only very large fish and the fish die shortly after being caught. Particularly useful for commercial fisherman and game and fish associations, they can be manipulated by one person and set up in about an hour. The nets are dropped into a lake or river and left for perhaps 24 hours. Fish are not able to see the fine strands of netting; so they swim right into the net. By the time they realize their peril, they have gone too far and their gills are caught in the net—like a fly in a spider web. Fish are often scarred or marked, and on the threshhold of death when finally pulled from the water. With an immediate market outlet for their catch, commercial fishermen find this technique quite satisfactory, but most people involved in aquaculture prefer to seine.

Seine Nets

Seine nets are used for harvesting all the fish from a pond at one time. Their mesh is much finer and made of a heavier fiber than gill nets in order to hold a whole catch without breaking. Lead weights attached to the bottom ropes prevent any fish from escaping the net as it is pulled across the pond. Floats attached to the top ropes complete the enclosure. To make the catch, the net is drawn across the pond and hauled out of the water at the other end. This is one task which requires a number of helpers.

Catfish Nets

Spines on the dorsal fins of catfish have a



Special netting material must be used for harvesting catfish to prevent snagging and injuring their spines.

tendency to get caught in nylon mesh netting. This can be harmful to the fish and to you if you attempt to free them without gloves, and can create a potential bottleneck in your harvesting project. Special nets coated with tar are available to help you avoid this problem.

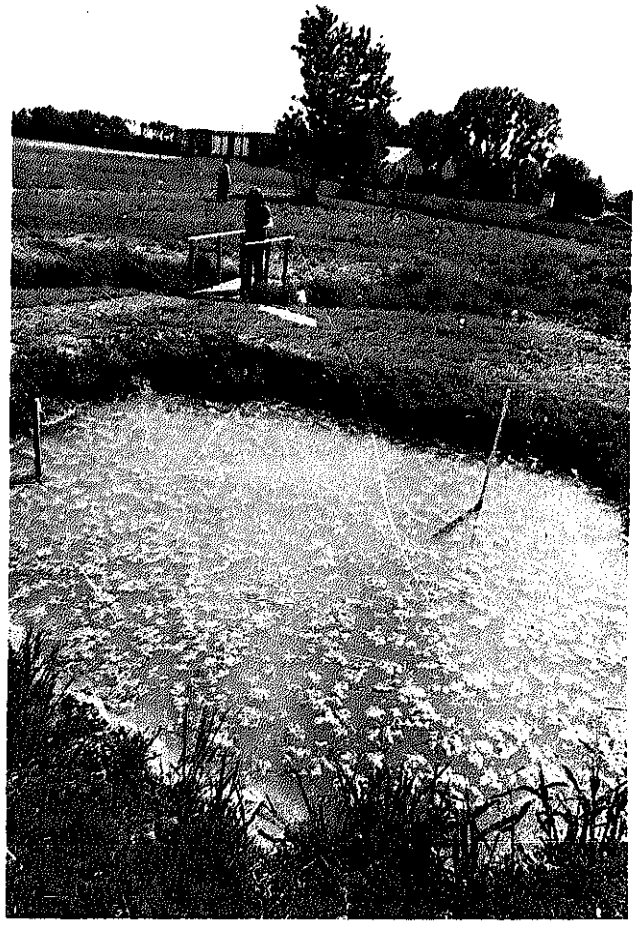
AQUATIC PLANTS

The control of aquatic weeds is a problem which plagues everyone involved with fish farming. If allowed to grow unchecked, water weeds will overrun ponds and lakes, reducing their water storage capacity, restricting water flow, and possibly harboring disease-carrying insects.

There is no permanent solution to this problem, but the longer weeds are left to flourish, the greater will be the expense of their eradication. Several methods are employed to remove weeds: mechanical devices, biological controls, chemical treatments, and cultural methods. For ecological reasons, we do not recommend chemicals, especially since sound alternatives are available.

Cultural and biological controls are still in the experimental stages. Certain species of fish, like the white amur and tilapia, feed on aquatic plants. They are illegal in most states because the effects of their introduction into a new environment are unknown. Researchers experimenting with biological control are stocking weed-laden ponds with only male fish to control the population of the species.

Such uncertainties bring us to mechanical devices as the most practical and ecologically



Algae blooms can rob fish of needed oxygen and cause massive fish kills.

sound means of aquatic weed control. Various cutting and dislodging tools are commercially available or can easily be made. Floating and submerged weeds can be controlled by manually picking or cutting them. A number of cutting devices can be used to harvest weeds from the bottom of a pond. It is important to remove cut aquatic vegetation from the water, as many of these plants reproduce through fragmentation (simple cell division) and would soon fill the pond again. Harvesting them for their contribution to the compost pile alone would be worth the effort.

Another effective weed control technique is lining the pond bottom with plastic to prevent plants from rooting. This method is quite expensive, and in larger ponds, is generally used only in the swimming area.

SOURCES OF WEED CUTTERS

Kee Underwater Weed Cutter

This weed cutter is designed to control underwater plant growth. It is comprised of two serrated blades which pivot forward and backward whenever the direction of movement is changed. The cutter comes with a 5-foot handle; an extra extension is also available. The cutter has a 3-month guarantee.

Kee Mfg. Co., Inc.
P.O. Box 2195
Bradenton, FL 33505

Joe Morreale and Son's Pond Sweeper

Plans for building your own pond sweeper are available by sending $3.00 to Joe Morreale. The unit is inexpensive to make, lightweight (12 pounds), and parts should be easy to find. It is operated by two people and is designed to gather weeds as they are cut, considerably simplifying disposal.

Joe Morreale
6805 Pioneer
Richmond, IL 60071

SOURCES OF FISH

Hatchery Listings

A list of all federal, state, and private hatcheries is available from:

National Marine Fisheries Service–National Oceanic and Atmospheric Administration
One Union Plaza, Suite 1160
Little Rock, AR 72201

When purchasing fish it is best to contact the closest hatchery. Transportation costs are high and stress to fish in transport may cause death.

Commercial Fish Farmers Buyers' Guide

The *Buyers' Guide* is published annually and contains a list of distributors and manufacturers of everything the fish farmer may need. The list is comprised of the magazine's advertisers' and subscribers' products.

Commercial Fish Farmer Subscription Service
P.O. Box 4992
Manchester, NH 03105

GOVERNMENT AGENCIES

There are a number of government agencies which provide literature and services for the pond owner. These services vary regionally, as some parts of the country are far more involved with fish farming than others. The best procedure is to contact a local office and ask specifically what information and services are available.

United States Fish and Wildlife Service–Division of Fisheries

The assistance offered by this agency varies in different parts of the country based upon the availability of fish in the area. In the southeastern United States, pond owners can apply to have their ponds inspected and stocked by the Service and receive the assistance of a staff fisheries biologist.

For those fortunate enough to have one of these offices nearby, there is a very important service offered. Each office has a disease control center where pond owners can send samples of dead fish to be analyzed. A staff member will identify the problem and advise what action should be taken. This resource is a comfort when fish appear floating belly up and the cause of death remains a mystery.

Soil Conservation Service

Again, the services offered vary regionally, but in all states the Soil Conservation Service will provide information about the suitability of soil for pond construction, design criteria, and stocking advice. Some states require a formal written request for assistance and will send agents prior to construction, while in other states, agents may stay during the entire construction and may stock the pond for free.

State Fish and Game Commission

In states where this agency is funded by revenue from fishing permits, this commission is forbidden by law to service private ponds. In the South, where fish farming is widespread, services may include free stocking, removal of trash fish, and assistance in restocking ponds. The Fish and Game Commission may also test to see what fish are already in your pond, and advise what should be done with them.

State Cooperative Extension Service

This service generally provides a wealth of information about pond design and management, balance of fish population, and methods of plant control. They can also advise of applicable United States Department of Agriculture publications.

Most extension services have agricultural engineers and/or wildlife experts on staff to advise about fish culture, and in some states, agents will run water-quality tests and assist with pond and stocking management.

United States Department of Agriculture Publications

The following publications are available free of charge (as long as the supply lasts) by writing to:

Publications Division
Office of Communication
U.S. Department of Agriculture
Washington, DC 20250

Write your name and address plainly on your order, and be sure to include your zip code. In general, not more than one copy each of 10 publications is allowed.

+F 2250	Warm Water Fish Ponds
+L 552	Trout Farming: Could Trout Farming Be Profitable for You?
+F 2249	Trout Ponds for Recreation
+MMR 993	Demand for Farm-Raised Channel Catfish in Supermarkets: Analysis of a Selected Market
+F 2256	Building a Pond

INTERNATIONAL DEVELOPMENT OF FISH FARMING

Most countries have government offices specifically geared towards international aquaculture development which are responsible for all project coordination. Often these agencies will contact other countries more actively involved with aquaculture for technical assistance. The United States Agency for International Development (USAID) and the Food and Agriculture Organization (FAO) are the two largest organizations involved with international aquaculture development. Both agencies have staff personnel trained to give technical assistance. Countries can apply to the World Bank for loans to finance their aquaculture projects. Generally, the World Bank will contact aquaculture experts for feasibility studies for a given country.

Addresses of International Offices

World Bank, International Bank for Reconstruction & Development
1818 H Street NW
Washington, DC 20433

USAID
Main State Building
Washington, DC 20523

FAO
Via Delle Terme Di Caracalla
00100 Rome, Italy

RECOMMENDED PUBLICATIONS

Magazines

Farm Pond Harvest

Published quarterly, this magazine includes such features as Aquaculture News, Questions

and Answers, Let's Go Farmpond Fishing, various articles about pond species and problems, tips for fish farmers, and advertising for many different types of small-scale equipment. The magazine is geared toward the small farm pond situation.

Farm Pond Harvest
Department M76
P.O. Box AA
Momence, IL 60954

Commercial Fish Farmer and Aquaculture News

Published bimonthly, this magazine features aquaculture news, columns, and sections about all species of cultured aquatic animals, organization news and meetings schedules, new developments both national and international, regular columns by various aquaculture experts, and a new products section. Advertisers are national distributors and manufacturers of aquaculture products and species.

Commercial Fish Farmer
Subscription Department
P.O. Box 631
Penacook, NH 03301

Fish Culture Section/American Fisheries Society Newsletter

You must be a member of the American Fisheries Society to receive this newsletter. Summaries of aquaculture events, conferences, legislation, new publications, workshops and symposiums, lists and directories, and pertinent aquaculture information are presented in this publication.

American Fisheries Society
5410 Grosvenor Lane
Bethesda, MD 20014

Books

The following books will provide fundamental understanding of pond ownership and management. Some are more technical and scientific than others, but all will provide valuable background information.

Hickling, C.F. *The Farming of Fish.* Elmsford, New York: Pergamon Press, Ltd., 1968.

This book provides the reader with an introduction to fish culture and offers an international perspective. It presents information which is basic to understanding pond ecology and productivity—water supply and quality, energy production and consumption within the pond, how the food chain applies to pond life, and the biology of and life cycles within the pond. It also compares aquaculture techniques of various countries.

Bardach, John E.; Ryther, John H.; and McLarney, William O. *Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms.* New York: John Wiley & Son, Inc., 1972.

The introductory chapter of this book discusses the general principles and economics of aquaculture. The following chapters deal with individual species, describing both commercial and small-scale culture, environmental and biological requirements, breeding information and population controls, and what a particular species has to offer for the fish farmer. It is a must for anyone involved in aquaculture because it provides specific requirements and information about all fish and shellfish commonly cultured.

Bennett, George W. *Management of Lakes and Ponds.* 2nd ed. New York: Van Nostrand Reinhold Co., 1971.

Bennett's book is geared to the professional fisheries biologist or the recreation expert designated to develop a body of water for sports fishing. It provides considerable general information about fish culture and discusses the history and theory of fish management. Other topics covered include water quality, carrying capacity and productivity of a given body of water, behavioral patterns of fish, production and growth potentials, and detailed information about angling.

Chakroff, Marilyn. *Freshwater Fish Pond Culture and Management.* VITA: Manual Series Number 36E, 1976.

This manual is a complete how-to for the aspiring pond owner. It is designed to provide basic information for the Peace Corps worker in Third World countries; so it is not technical or highly scientific. It details pond siting and construction, management and harvesting techniques, and control of diseases, parasites, and predators. The manual is also full of plans, recipes, and homemade treatments.

Scott, W.B., and Crossman, E.J. *Freshwater Fishes of Canada*. Ottawa: Fisheries Research Board of Canada, 1973. Bulletin 184.

Many of the species of freshwater fish found in Canada can also be found in the United States. This book provides detailed information on many species of fish including anatomical sketches, descriptions, distribution, biological requirements, nomenclature, and relation to man. It also has an extensive glossary, many suggested readings, and a lengthy reference section. It is a valuable tool in providing the reader with the means of finding a wealth of material about many species of fish.

Podems, Marc, and Ruttle, Jack. *A Guide to Small-Scale Fish Culture*. Emmaus, Pennsylvania: Rodale Press, 1978.

This primer is a must for any would-be fish farmer. It describes how to raise fish in a pond or a pool or even in your basement in simple, easy-to-understand language. Its chapters include discussions on selecting the right species for given circumstances, caring for the fish, managing the water, estimating costs, and water ecology. In addition, sources for supplies, fish, and references to expert advice are listed in the appendix. It is illustrated with drawings of fish and is available without charge from *Organic Gardening* Readers' Service, Rodale Press, 33 E. Minor Street, Emmaus, PA 18049.

Logsdon, Gene. *Getting Food from Water: A Guide to Backyard Aquaculture*. Emmaus, Pennsylvania: Rodale Press, 1978.

This book, published in fall of 1978, is geared for the hobbyist interested in raising his own food and possibly making a small profit. It covers a wide range of topics from edible water plants to raising ducks to ice and ice houses. This book is not limited to procuring food from a farm pond only, but also tells how to get food from the wild. The first section of the book deals with naturally occurring bodies of water, and the second section deals with constructed ponds, tanks, and raceways.

Hale, P.R., and Williams, B.D., eds. *Liklik Buk*. Lae, Papua, New Guinea: Liklik Buk Information Center, 1977.

This handbook of intermediate technology in Papua, New Guinea has a brief section devoted to the local fish culture project. Dealing with tilapia, its chapters describe the economics, processing, and marketing of the fish.

Liklik Buk Information Center
P.O. Box 1920
Lae, Papua, New Guinea

BIBLIOGRAPHIES

Bibliographies of available publications on aquaculture can be ordered from:

Publications Clerk, 249 Ag Center
School of Forestry & Wildlife Management
Louisiana State University
Baton Rouge, LA 70803

Ask for the aquaculture bibliography:
OG Readers' Service
Rodale Press, Inc.
33 E. Minor St.
Emmaus, PA 18049

Ask for *The Progressive Fish-Culturist:*
Superintendent of Documents
United States Government Printing Office
Washington, DC 20402

Appendix A: NORTH AMERICAN MANUFACTURERS AND DISTRIBUTORS APPEARING ON CHARTS IN THIS BOOK

Agway, Inc.
P.O. Box 1333
Syracuse, NY 13201

Allied Farm Equipment
3721 Mahoning Ave.
Youngstown, OH 44509
or
101 Eastern Ave.
Syracuse, NY 13211
or
124 Labrosse Ave.
Pointe Claire, Quebec, Canada

Allis-Chalmers
Box 512
Milwaukee, WI 53201

Amerind-MacKissic, Inc.
P.O. Box 111
Parker Ford, PA 19457

Ames
Box 1774
Parkersburg, WV 26101

Anchor Tools & Woodstoves
618 NW Davis
Portland, OR 97209

Ariens Co.
655 W. Ryan St.
Brillion, WI 54110

Atlas Tool & Mfg. Co.
5151 Natural Bridge Ave.
St. Louis, MO 63115

Auto-Hoe, Inc.
P.O. Box W121
Lost Dauphin Dr.
DePere, WI 54115

Belknap, Inc.
P.O. Box 28
Louisville, KY 40201

Black & Decker
Towson, MD 21204

Brantly Mfg. Co., Inc.
516 W. Grand
Frederick, OK 73542

Brinly-Hardy Co., Inc.
P.O. Box 1116
Louisville, KY 40201

Brown Mfg. Corp.
Ozark, AL 36360

W. Atlee Burpee Co.
300 Park Ave.
Warminster, PA 18974

J. I. Case Co.
Outdoor Power Equipment Div.
Winneconne, WI 54986

Central Tractor distributed by:

Weaver's Hardware Co.
RD 2, Lyons Rd.
Fleetwood, PA 19522

Chromalloy Farm & Industrial Equipment Co.
Crescent Div., Pear & Tinkham Sts.
Box 549
Havana, IL 62644

Cole Mfg. Co.
1318 Central Ave.
Charlotte, NC 28299

Columbia Cutlery Co.
P.O. Box 123
Reading, PA 19603

Continental Belton Co.
P.O. Box 660
Belton, TX 76513

Corsicana Grader & Machine Co.
P.O. Box 1699
Corsicana, TX 75110

Countryside Catalog
Rt. 1, Box 239
Waterloo, WI 53594

Cumberland General Store
Rt. 3, Box 479
Crossville, TN 38555

John Deere
Moline, IL 61265

DeGiorgi Co., Inc.
Council Bluffs, IA 51501

The Derby Tiller Co.
P.O. Box 21
Rumson, NJ 07760

Detroit Tool & Engineering
The Garden Maid Div.
P.O. Box 232
Lebanon, MO 65536

Edko Mfg. Co.
P.O. Box 111
Rocky Ford, CO 81067

Edko Mfg., Inc.
2725 Second Ave.
Des Moines, IA 50313

Edwards Equipment Co.
4312 Main St.
Yakima, WA 98903

Empire Plow Co.
3140 E. Sixty-fifth St.
Cleveland, OH 44127

Farm & Fleet
1600 E. Lincoln Hwy.
DeKalb, IL 60115

Farnam Equipment Co.
P.O. Box 12068
Omaha, NE 68112

FMC-Bolens
Outdoor Power Equip. Div.
215 S. Park St.
Port Washington, WI 53074

Ford Motor Co.
Troy, MI 48084

Forestry Suppliers, Inc.
205 W. Rankin St., Box 8397
Jackson, MS 39204

Dean Foster Nurseries
Hartford, MI 49057

Fuerst Brothers, Inc.
Rhinebeck, NY 12572

Gantt Mfg. Co.
Box 49
Macon, GA 31202

Gilmore-Tatge Mfg. Co., Inc.
Clay Center, KS 67432

Gilson Brothers Co.
Box 152
Plymouth, WI 53073

Gilson Brothers Co., Ltd.
3325 Orlando Dr.
Mississaugua, Ontario, Canada

Glen-Bel's Country Store
Rt. 5, Box 390
Crossville, TN 38555

Hahn, Inc.
Outdoor Products Div.
1625 N. Garvin
Evansville, IN 47717

Heald, Inc.
Dept. DTB, P.O. Box 148
Benton Harbor, MI 49022

IMCO-Independent Mfg. Co., Inc.
Industrial Park
Neodesha, KS 66757

International Harvester Co.
The Good Earth Catalog
P.O. Box 1008
Tinley Park, IL 60477

International Modern Machinery, Inc.
P.O. Box 790
Beaumont, TX 77704

Jeoffrey Mfg., Inc.
P.O. Box 9114
Amarillo, TX 79105

KMC (Kelly Mfg. Co.)
South Industrial Park
P.O. Box 1467
Tifton, GA 31794

Koehn Mfg. & Dist., Inc.
Watertown, SD 57201

John R. Kovar Mfg. Co., Inc.
6043 Hwy. 10 NW
Anoka, MN 55303

K-W Mfg. Co., Inc.
800 S. Marion Rd.
Sioux Falls, SD 57106

Lehman Hardware & Appliance, Inc.
Box 41
Kidron, OH 44636

A. M. Leonard & Son, Inc.
P.O. Box 816
Piqua, OH 45356

Magna American Corp.
Box 90
Raymond, MS 39154

McDonough Power Equipment
McDonough, GA 30253

The Ben Meadows Co.
3589 Broad St.
Atlanta, GA 30366

Merry Mfg. Co.
Box 168
Marysville, WA 98270

Montgomery Ward
1000 S. Monroe St.
Baltimore, MD 21232

Mother's General Store
Box 506
Flat Rock, NC 28731

MTD Products, Inc.
5389 W. 130th St., P.O. Box 2741
Cleveland, OH 44111

Nasco Agricultural Sciences
901 Janesville Ave.
Fort Atkinson, WI 53538

Noble Mfg. Co.
see Royal Industries

Northeast Carry Trading Co.
110 Water St., P.O. Box 187
Hallowell, ME 04347

Oley Tooling, Inc.
Oley, PA 19547

Pengo Corp.
Sunnyvale, CA 94086

Planet Plows, Inc.
P.O. Box 3779
Amarillo, TX 79106

Roper Sales
1905 W. Court St.
Kankakee, IL 60901

The Roto-Hoe Co.
100 Auburn Rd.
Newbury, OH 44065

Royal Industries
Noble Div., Dept. FI-6
Sac City, IA 50583

G.E. Ruhmann Mfg. Co., Inc.
801 S. Main St.
Schulenburg, TX 78956

Scovil Hoe Co.
P.O. Box 328
Locust Valley, NY 11560

Sears, Roebuck & Co.
Farm and Ranch Catalog
Available at any Sears store.

Sensation Corp.
7577 Burlington St.
Ralston, NE 68127

Seymour Mfg. Co.
3300 N. Broadway
Seymour, IN 47274

Simplicity Mfg. Co., Inc.
Port Washington, WI 53074

Southeast Mfg. Co., Inc.
Rt. 2, Box 275
Joplin, MO 64801

SpeeCo (Special Products)
15000 W. 44th Ave., P.O. Box 592
Golden, CO 80401

Also available from TSC & Central Tractor.

Stanley Garden Tools, U.S. Distributor
Woodcraft Supply Corp.
313 Montvale Ave.
Woburn, MA 01801

Stanley Hydraulic Tools
13770 S.E. Ambler Rd.
Clackamas, OR 97015

Taylor Implement Mfg. Co.
Athens, TN 37303

Tractor Supply Co.
7910 L St.
Omaha, NE 68127

Tradewinds, Inc.
P.O. Box 1191
Tacoma, WA 98401

True Temper Corp., Hardware Div.
1623 Euclid Ave.
Cleveland, OH 44115

True Value Hardware
2740 Clayburn Ave.
Chicago, IL 60614

The Union Fork & Hoe Co.
500 Dublin Ave.
Columbus, OH 43216

United Farm Tools, Inc.
P.O. Box 9175-32
South Charleston, WV 25309

Utility Tool & Body Co., Inc.
Clintonville, WI 54929

The Vassar Co.
Perkins, OK 74059

Wikomi Mfg. Co.
P.O. Box 100
Litchfield, IL 62056

Appendix B: INTERNATIONAL MANUFACTURERS AND DISTRIBUTORS APPEARING ON CHARTS IN THIS BOOK

ACM Equipments
Bienvillers 62111 Foncquevillers
Boite Postale 5, France

African Hoe (Pty.), Ltd.
477 Watt Rd., New Era Industrial Sites
Springs Transvaal, Rep. of S. Africa 1560

Agrator Industrial, S.L.
Ctra. Bilbao por Murguia km. 5,5
P.O. Box 316
Vitoria, Spain

Agria-Werke Gmbh
7108 Moeckmuehl
P.O. Box 47/48
West Germany

Agromet Motoimport
Entreprise Du Commerce Exterieur
Warszawa, Przemyslowa 26, Poland

Bomford & Evershed, Ltd.
Salford Priors, Evesham
Worcestershire WR11 5SW, England

Bulldog Tools U.S. Distributor
Jim Everett, Dobson Park Industries, Ltd.
Suite 400, 4041 N. High St.
Columbus, OH 43214

Caralel Enterprise Co., Ltd.
P.O. Box 59442
Taipei, Taiwan

CEAF
S.N.C. Filli Siletti
24034 Cisano
Bergamasco, Italy

CeCoCo Agricultural & Small Industrial Center
P.O. Box 8, Ibaraki City
Osaka Pref. 567, Japan

Cepelia
236 Fifth Ave.
New York, NY 10017

The Chillington Tool Co., Ltd.
P.O. Box 45, Hickman Ave.
Wolverhampton WV1 2BU, England

Coopexim-Cepelia
Zurawia 4, 00-950 Warsazawa
Poland

Cossul and Co. Pvt., Ltd.
Industrial Area, Fazalgunj
Kanpur, India

E.B.R.A. (Ets Beauvais & Robin)
28 rue du Maine, B.P. 84
49009 Angers, France

English Tools, Ltd. (Bulldog Tools)
Clarington Forge
Wigan, Lancasnire, England

Ets Delaplace
02590 Etreillers (Aisne)
R.C. Saint-Quentin 63 A 113, France

Fabriche Riunite Falci
Dronero, Via Cuneo 3/5/7
Cuneo, Italy

Ferfor
Rua Da Amieira, P.O. Box 16
S. Mamede De Infesta, Portugal

Ferunion
Hungarian Trading Co. for Technical Goods
1829 Budapest
P.O.B. 612, Hungary

OY Fiskars AB
P.O. Box 235, Mannerheimintie 14
Helsinki, Finland

F. W. K.'sche Eisenwerke
Aktiengesellschaft Adolfshutte
Postfach 260, D 6340 Dillenburg
Federal Republic of Germany

CG Funcke Sohn
58 Hagen
Postfach 1109, West Germany

Gherardi
Office Machine Agricole Industriali
Jesi (Ancona) Via Gallodoro 68, Italy

Hako-Werke
2060 Bad Oldesloe 1
P.O. Box 1444, West Germany

Herragro
Apartado Aereo 1003
Manizales, Colombia

W. Hertecant
9200 Kwatrecht
Wetteren, Belgium

Hilton Enterprise Co., Ltd.
P.O. Box 36-370
Taipei, Taiwan R.O.C.

Hindustan Engineering Co.
Aban House, 25/31 Ropewalk St.
Rampart Row, Fort Bombay 400 023, India

T & J Hutton Co., Ltd.
Phoenix Works, Ridgeway 11
Sheffield S12 3XW, U.K.

Industrias Metalurgicas Apolo S.A.
Carrera 50-2 Sur-189 Autopista Sur
Medellin, Antioqui, Colombia

ISEKI Agricultural Machinery Mfg. Co., Ltd.
1-3, Nihonbashi 2-chome, Chuo-ku
Tokyo 103, Japan

Jenks & Catell, Ltd.
Phoenix Works, Wednesfield
Wolverhampton, WV11 3PV, England

Jumil
Justino de Morais, Irmaos S.A.
Rua Ana Luiza, 568
Batatais S.P., Brazil

Kuhn S.A.
67700 Saverne
France

Kuhn, U.S.
Box 224
Vernon, NY 13476

Kumaon Agri-Horticulture Stores
P.O. Kashipur
District Nainital U.P., India

Kumaon Nursery
Ramnagar
Nainital U.P., India

Kumar Industries
Edathara Post, Palphat District
Kerala State, South India

Kvernelands Fabrikk A/S
N-4344 Kverneland
Norway

Lasher Tools (Pty.), Ltd.
P.O. Box 254
Germiston 1400 Transvaal, S. Africa

Ralph Martindale & Co., Ltd.
Crocodile Works, Alma St.
Birmingham B19 2RR, England

Mechanized Gardening
Great Gransden, Sandy
Bedfordshire SG19 3AY, U.K.

Mobinder & Co. Allied Industries
Kurali, Dist. Ropar
Punjab, India

Nardi Macchine Agricole
06017 Selci Lama
Perugia, Italy

Nikko Co., Ltd.
1, 5-chome, Shinmachi
Minami-dori, Nishi-ku
Osaka, Japan

Oy Rettig-Strengberg Ab
Metal Industry Purmo
P.O. Box 16
SF 68601 Jakobstad, Finland

Peugeot, Division Outillage
66 a 78, Avenue Francois Arago
92 002, Nanterre, France

Pierce of Wexford—member of:
Britain Group Sales, Ltd.
Agricultural Division
P.O. Box 143, Naas Rd.
Dublin 12, Ireland

George Pike, Ltd.
Equipment Works
Alma St., Aston
Birmingham B19 2RS, England

Polar-Werke, Engels & Sieper
Postfach 14 02 24/25
5630 Remschied 14, West Germany

Purmo Produkt AB
Jakobstad, Sweden

Schanzlin Maschinenfabrik Gmbh
7831 Weistweil
Baden, West Germany

SHW Schwabische Huttenwerke Gmbh
Postfach 1329
7292 Baiersbronn-Friedrichstal
West Germany

Self-Sufficiency and Small-Holding Supplies
The Old Palace, Priory Rd.
Wells, Somerset BA5 1SY, England

Societe des Forges Tropicales
B.P. 706
Douala, Cameroun

Solo Kleinmotoren Gmbh
7032 Sindelfingen 6
Postfach 20, West Germany

Franz Sonnleithner K.G.
4460 Losenstein/Laussa 25
Austria

Spear & Jackson Tools, Ltd.
St. Paul's Rd., Wednesbury
Staffordshire WS10 9RA, England

Stanley Garden Tools, Ltd.
Woodhouse Mill
Sheffield S13 9WJ, England

Staub–Societe des Tracteurs & Motoculteurs
25, BD DeVerdun
Courbevoie Cedex, France

Syndicat de L'Outillage
Agricole et Horticole
15 rue Beaujon
75008 Paris, France

Tanzania Agricultural Machinery Testing Unit
P.O. Box 1389
Arusha, Tanzania

The Tata Iron & Steel Co., Ltd.
43 Chowringhee Rd.
Calcutta 16, India

Tonutti, S.P.A.
Remanzacco
33047 UD 063, Italy

W. Tyzack Sons & Turner, Ltd.
Little London Works
Sheffield S8 OUE, England

Ubungo Farm Implements
P.O. Box 2669
Dar Es Salaam, Tanzania

Vilhard & Co.
Postfach 7
6126 Brombachtal (Odenwald), West Germany

Wolf & Bankert
Werkzeug Fabrik
563 Remschied, West Germany

Wolf Tools for Garden & Lawn, Ltd.
Ross-on-Rye
Herefordshire HR9 5NE, England

Wolseley Webb, Ltd.
Electric Ave., Witton
Birmingham B6 7JA, U.K.

Yanmar Diesel Engine Co.
1-11-1, Marunouchi, Chiyoda-ku
Tokyo, Japan

Appendix C: CONVERSION FACTORS: U.S. AND METRIC UNITS

These conversion tables will come in handy if you're interested in any pieces of foreign equipment. They were supplied by Seedburo Equipment Co.

METRIC TO U.S.

LENGTH			
1 millimeter	=	0.04	inch
1 meter	=	3.3	feet
1 meter	=	1.1	yards
1 kilometer	=	0.6	mile
AREA			
1 sq. centimeter	=	0.16	sq. inch
1 sq. meter	=	11.0	sq. feet
1 sq. meter	=	1.2	sq. yards
1 hectare	=	2.5	acres
1 sq. kilometer	=	0.39	sq. mile
VOLUME			
1 cubic centimeter	=	0.06	cubic inch
1 cubic meter	=	35.0	cubic feet
1 cubic meter	=	1.3	cubic yards
1 milliliter	=	0.2	teaspoon
1 milliliter	=	0.07	tablespoon
1 milliliter	=	0.03	ounce
1 liter	=	4.2	cups
1 liter	=	2.1	pints (liq)
1 liter	=	1.1	quarts (liq)
1 cubic meter	=	264.0	gallons (liq)
1 cubic meter	=	113.0	pecks
1 cubic meter	=	28.0	bushels
MASS			
1 milligram	=	0.015	grain
1 gram	=	0.035	ounce (dry)
1 kilogram	=	2.2	pounds
1 metric ton	=	1.102	tons (short)

Temperature °C Celsius x 9/5 and add 32° = °F.

U.S. TO METRIC

LENGTH			
1 inch	=	25.4	millimeters
1 foot	=	0.3	meter
1 yard	=	0.9	meter
1 mile	=	1.6	kilometers
AREA			
1 sq. inch	=	6.5	sq. centimeters
1 sq. foot	=	0.09	sq. meter
1 sq. yard	=	0.8	sq. meter
1 acre	=	0.4	hectare
1 sq. mile	=	2.6	sq. kilometers
VOLUME			
1 cubic inch	=	16.4	cubic centimeters
1 cubic foot	=	0.03	cubic meters
1 cubic yard	=	0.76	cubic meters
1 teaspoon	=	5.0	milliliters
1 tablespoon	=	15.0	milliliters
1 fl. ounce	=	29.6	milliliters
1 cup	=	0.24	liter
1 pint (liq)	=	0.47	liter
1 quart (liq)	=	0.95	liter
1 gallon (liq)	=	0.004	cubic meter
1 peck	=	0.009	cubic meter
1 bushel	=	0.04	cubic meter
MASS			
1 grain	=	64.8	milligrams
1 ounce (dry)	=	28.3	grams
1 pound	=	0.45	kilogram
1 short ton	=	9.072	kilograms

Temperature of Fahrenheit x 5/9 after Subtracting 32° = °C.

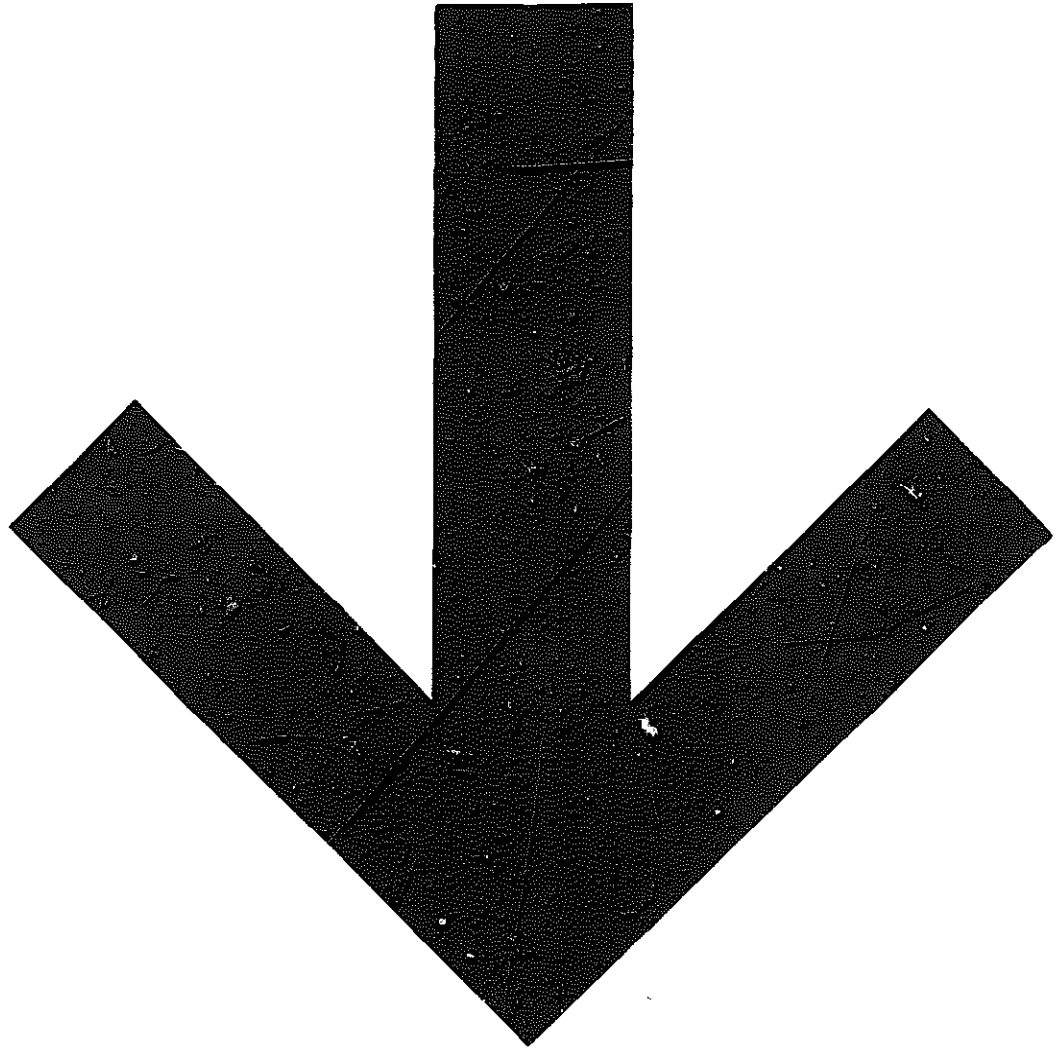
TONS TO BUSHELS CONVERSION

Conversion factors by grain:

Grain	Short	Metric	Long
Wheat	33.333	36.743	37.333
Corn	35.714	39.368	40.000
Soybeans	33.333	36.743	37.333
Barley	41.667	45.929	46.667
Oats	62.500	68.894	70.000

Wheat	60 lbs. per bu.
Soybeans	60 lbs. per bu.
Corn	56 lbs. per bu.
Barley	48 lbs. per bu.
Oats	32 lbs. per bu.

A Short Ton is 2,000 pounds.
A Metric Ton is 2,204.6 lbs.
A Long Ton is 2,240 pounds.



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